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A HANDBOOK OF FORESTRY

BY

W. F. A. HUDSON, M.A.

THE COOPER LABORATORY
FOR ECONOMIC RESEARCH
WATFORD

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A Handbook of Forestry

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FORESTRY
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PREFACE

ESTATE owners often say that it does not pay to grow trees—or that "forestry does not pay." Under certain conditions this may be so; but a very slight acquaintance with the rudiments of forestry makes it obvious that the great majority of trees are planted without regard to the species of tree most suitable for the land, and to the local conditions, and, further, that when planted they are not given that small amount of attention which is really necessary for their welfare.

Whether a knowledge of the elements of forestry, alone, would make the difference between profit and loss is not possible to say definitely; but it seems to me that such ought to be the case. It is certain, however, that there would be a great improvement in results if only some amount of knowledge and experience were brought to bear upon the question.

In journeying through the country, one observes many pieces of waste land quite unsuitable for any agricultural purpose. Such land could be turned to profitable use if it were planted with suitable trees, and if only these trees had that proper care and attention which the elementary principles of forestry dictate.

One and probably the chief reason why so little attention has been given to the planting of such readily available sites is that a cheap and simple handbook, giving in outline the leading principles of forestry, was wanted. The ordinary estate manager has no time to read and digest the larger textbooks on the subject, and for that reason Mr. W. F. A. Hudson was asked to write this short treatise, which it is hoped will provide the landowner and steward with such adequate information on the general principles of practical forestry as will enable him at least to realise the importance of the subject, and such guidance as will assist him to initiate more systematic and correct methods of dealing with the land, whether it be existing woodland, or waste land calling for profitable development.

W. F. COOPER.

THE COOPER LABORATORY
FOR ECONOMIC RESEARCH,
WATFORD, *February*, 1913.

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CHAPTER I

INTRODUCTION

THE primary object of this short treatise is to provide a handy and concise guide for the general estate manager, whose duties usually include the care and management of woodland. In most cases, he has no time to make a special study of forestry, or to select from more comprehensive works just the kind of information which he requires.

Most estates are managed by a man who has been trained in agriculture especially, his main duties consisting of the management of live stock, agricultural land, etc. It is exceptional, however, to find that his qualifications embrace an expert knowledge of forestry; and this accounts for the errors which are committed in this branch of estate-management. It has been felt that a short handbook on the subject, comprising most of the essential points, but avoiding details, would prove an acceptable and useful guide. In writing this book, the author has omitted arguments and reasons for the chief methods advocated; he has been anxious to present only the most important portions of the subject, because he recognises that the estate manager, in most cases, is thoroughly conversant with the principles of "growth," and that he will be able, therefore, to see the "why and the wherefore" for himself.

There is no doubt whatever that most estates would be better if the wooded portions were placed under the management of a competent forester; but the usual English estate is seldom sufficiently extensive as to be able to bear the expense of a man solely for this purpose. Indeed, the requirements of an ordinary estate are such that his time could not possibly be fully occupied, and he could just as well manage several estates, or he could give his services to a whole district. Thus, it would seem to be a wiser arrangement if one man could be appointed to give advice to the estates of a whole district. Such an arrangement would not only benefit the estates individually, but also the whole country.

The condition of forestry in this country is deplorable, as is evident from the recent interest and agitation in favour of reafforestation; and there is very little chance of improvement until some far-seeing individual or society decides to take the matter in hand. Yet, if all those engaged in the management of woodland would make themselves acquainted with the general principles of forestry, many mistakes would be avoided and much could be done to rectify the errors of a past generation.

The question is often asked, "Does forestry pay in this country?" and, apparently, much doubt exists on the subject. One aspect of the question is perfectly clear: that forestry conducted in the present haphazard fashion cannot pay; and nothing short of periodic and careful supervision by a competent man, from the time of planting to the time of cutting, could ensure a proper return. It should be remembered that this period occupies the working lives of two generations at least; and a mistake once made, or any considerable break in the continuity of the supervision, may have the effect of spoiling the work of a lifetime. Faulty methods, even when practised for a few years only, induce faults in the wood which will persist to the end of the rotation, and which will diminish the value of the produce. In the case of a farm, the worst managed land in the world is capable of being put into good order in a few years; and the farmer is able to rectify his mistakes each season from the experience gained during the previous one. In forestry, however, the conditions are entirely different, since the period of rotation may be from 50 to 100 years. Thus, a good forester, if he has the misfortune to succeed a bad one, may be unable to rectify the initial errors; or, in any case, he may find his work most difficult to accomplish satisfactorily.

Home-grown timber is often condemned; and justly so, as it is usually rough and full of knots. This is caused by insufficient attention to the *principles of forestry, the aim and object of which is to produce, from a given area, the maximum amount of marketable timber under varying conditions.* Another point is that the timber is usually placed on the market in uncertain quantities, so that timber merchants find it hardly worth their attention when they can buy exactly what they want from abroad. It is not infrequently the case that timber is felled prematurely in order to provide money for the proprietor, with the result that the ultimate crop is ruined. This is equivalent to the action of the tenant farmer who "farms to go." The amount of timber cut out of a wood each year should not be more than the amount produced in the same period. The timber cut from the wood may be regarded as the income; whereas the trees which are left, and the ground on which they stand, represent the capital; and care must be taken that this capital is not diminished.

The amount of timber produced each year is termed "annual increment." An ordinary computation, for land of average quality, is 50 cubic feet per acre per annum. To get the best return from land, there must be a "*Working Plan*"; in other words, *a definite system which maps out the future of a wood, and which ensures a periodic fall of timber and a periodic planting,* the result being a periodic income of constant amount. The formation of such a working plan involves an intimate knowledge of forestry, especially that branch of it which is termed "*Assessment of the Locality.*"

The answer to the question, "Does forestry pay?" therefore, depends upon whether or not its operations have been conducted under competent supervision. In the former case, the reply is emphatically "Yes." This is amply proved by the importance given to economic forestry in such countries as Germany; but, as an illustration from this country is likely to offer more convincing testimony, the reader is referred to the following figures taken from J. D. Sutherland's book, "A General Description of the Woods on the Appin Estate in Argyllshire, belonging to Mr. J. R. MacAlpine-Downie of Appin," 1908 :—

The Knap Woods of 15 Acres.

The following sales are recorded from this ground :—

In 1889 : 910 Larch and 6 Oak, realised	£530	0	0
In 1899 : 1928 Larch, 83 Spruce, and 73 Scotch Fir, brought ...	800	0	0
Or 3000 trees yielded	£1330	0	0
Of the area, about one acre is outcrop rock, so that roughly 14 acres would have been originally planted. Probably 49,644 young plants were used, *i.e.*, at 3½ feet apart, or 3,546 per acre. If we set aside 24,644 trees for weeding and loss—roughly 50%—and deduct the 3000 sold as above, it may be fairly estimated that 22,000 trees were marketed or used prior to 1888. It was almost a pure larch wood, and putting the value of the remaining 22,000 trees at 2/6 each over all, this would give ...	2750	0	0
Or a total revenue of	£4080	0	0
The capital outlay for planting and enclosing would have been, say, £70, or £5 per acre, 100 years ago. Adding 2% on £70 over this period, at compound interest (2% is taken as a medium, because returns of capital would have been received from time to time), and the result is	£486	14	5
Add the grazing rent (14 acres at 2/6 per acre), £1 15s. per annum, at 3% compound interest over 60 years—the grazing rent has been obtained for the last 40 years ...	283	10	0
Further allow for rates and taxes, working and management, £10 10s. per annum for 60 years, with 3% compound interest ...	1701	0	0
	£2471	4	5

This shows a balance in favour of the timber crop as against the grazing rent, of £1608 15s. 7d., or more than £1 per acre per annum over 100 years. The wood might have been cut thirty years ago with similar returns; but, as it was in a prominent situation, it was allowed to stand beyond the proper time for felling. The land is on the sea-board, on a conical promontory without shelter. The soil is of moderate quality, naturally well drained, and the stone underneath is Ardrishaig Phyllites.

From these figures it will be seen that excellent profit results under good management.

The "*Assessment of the Locality*" is one of the most important points in the consideration of any problem of afforestation. *It includes consideration as to what should be planted, and how it should be grown; with special reference to all conditions existing in the district*, including not only the class of trees suited to the soil and climate, but also the local demands for timber, the cost of haulage, and even such details as the cost of labour for felling, etc. Having once reviewed the possibilities of the district—having made an "Assessment of the Locality," in fact—the forester has to formulate a method for achieving his ends in the most economical and profitable manner. The general conception has been referred to, already, as the "Working Plan," and it cannot be discussed in greater detail here. It includes a choice of species—or mixture of species—which are to be planted originally; and a decision as to what is to take the place of the trees felled, and so on. It is in this preliminary work, perhaps, more than in the management of the trees when planted, that the advice of a competent forester is invaluable. Much of the trouble with our English timber results from errors in the "Working Plan"—or more generally from its total omission—as well, also, as in the failure to make a correct "Assessment of the Locality." As already stated, the principal reason for adopting a working plan is to ensure a periodic income. To ensure, as far as possible, an equal periodic fall of timber, demands an intimate knowledge of the inherent capabilities of the soil, suitability of the species to the locality, and also the probable future demand for timber of the species planted. These points can only be determined by the expert, and even he may be handicapped by the absence of reliable statistics.

Now that the problem of the reafforestation of the British Isles is taking so prominent a place, it becomes all the more important that the ordinary estate manager should be acquainted with the chief principles of forestry. It is hoped that this book may not only stimulate interest in the subject, but also that it should present, in a concise form, those important essentials of the subject without which any work on the woodland districts of an estate would be more or less wasted labour.

CHAPTER II

THE NURSERY

THE majority of trees grown in this country are raised from seed, the principal exceptions being elms, poplars, limes, and willows. It cannot be impressed too emphatically upon every owner of land who does even a small amount of planting each year, that a small private nursery is practically essential to the well-being of his woods.

The advantages are : —

(1) Whereas with a home nursery a few plants may be planted, accordingly as labour and weather allow : without a home nursery a large number of plants must be purchased at one time. These, on arrival, must be planted without delay, or else they must be "heeled" ; in the former case, it may be inconvenient to provide the labour at once ; in the latter case, the vitality of the plants suffers.

(2) The plants become acclimatised to the particular conditions under which they are to be grown, and they may be left in the ground until the season is favourable.

(3) Damage from frost, drought, or the heating of the plants during a journey is avoided.

An objection which is sometimes raised to the home nursery, is that the ordinary working forester has not sufficient skill required for nursery work. Care and common sense, however, are all that is required. The chief difficulty lies in the raising of the seedlings ; but even so, seedling plants may be purchased, and lined out in the nursery. Moreover, self-sown seedlings may be taken from the woods and lined out, as described later. But the author's experience leaves him no hesitation in strongly advocating a home nursery.

The site of the nursery is important, especially as regards frost and drought. An eastern slope should be avoided ; for, in the spring-time, the rays of the rising sun strike directly upon the shoots which have been frozen during the night, and this is detrimental to the plants, owing to the rapidity of the thaw. The more gradual thaw, which takes place on other aspects, is far less dangerous. A southern slope is very good on soils inclined to be cold, but it is objectionable on a soil liable to "burn." Low-lying ground or hollows are also bad, because frost is more severe in such places, owing to the fact that the cold air, being more heavy than hot air, lies stagnant in them.

As regards the soil, a deep loam is the best; clay, and peat, and thin gravelly soils are the worst. It must be remembered that it is not advisable to have *too* fertile a soil for a nursery, if the plants grown in it are destined for the thin soil of an exposed hill-side. It is sometimes argued that a young tree destined for an exposed hill-side, where the soil is poor, will feel the change less if the soil of the nursery resembles that of the hill-side. This, however, is carrying theory to excess. A plant, to do well, must be well nourished with a properly developed root-system, and it must have plenty of root fibre.

The arrangement of the nursery, if merely a temporary one, requires very little beyond subdivision into rectangular beds. These should be not more than three feet six inches wide, so that they can be weeded without stepping on the bed. They should, of course, be fenced securely from ground game. If the nursery is of a permanent character and of modest size, however, it is essential to have one or more cartways, the construction of which may be left to the discretion of the proprietor. Facilities for watering are also advisable. Shelter, if not already provided, may be secured by privet hedges so placed as to intercept the prevailing winds.

As to manuring, the direct application of farmyard manure to young trees is not advisable; still, it is of course necessary to keep the ground in fair manurial condition.

The whole of the nursery should have a preliminary crop before any trees are planted or sown, and potatoes are suitable for this purpose. In this way the ground is well cultivated and cleaned, and the unexhausted residue is available for the young trees. The best method of maintaining the manurial condition of the soil is to grow some crop, each year, upon one-fourth or one-fifth of the nursery. To this crop, a liberal dressing of dung is applied, so that the whole of the nursery is manured every four or five years. After the seedlings are taken out—in about two years—the transplants take their place; after the transplants, another fallow crop with a further quantity of dung secures efficient manuring for the whole period.

Sowing and Transplanting.

The sowing of the seeds of trees is done either broadcast or in drills. Broadcast sowing is the most usual method; but more seed is required than when sowing in drills, and, therefore, the latter method is advisable for rare or expensive seeds.

Broadcast sowing is conducted as follows:—A tilth is prepared, which must be fine for small seeds; the surface soil is then drawn aside to the required depth with a broad hoe. The surface is then rolled with a light wooden roller measuring about nine inches in diameter and two to three feet wide. The seed is scattered over the whole surface; the soil is then drawn back, and the roller is passed over to press it down. This is done by two men walking on each side of the bed on the boundary paths, so as to avoid treading on the soil. The handle of the roller should be of sufficient length to project on each side of the bed.

The depth of sowing is important. If the depth is too great the young plant is either weakened or killed. The general rule is to regulate the depth of sowing to the amount of reserve material known to be possessed by the seed. Hence, Scotch pine, larch, spruce, etc., should have a covering of soil of not more than a quarter of an inch; whereas, on the other hand, the larger seeds of the broad-leaved trees, such as oak, chestnut, etc., may have a covering of soil of from one to two inches in depth.

It will be understood, of course, that it is essential that the bed is not trodden upon, and that advantage is taken of a suitable condition of humidity, as is done by the gardener or farmer when sowing his crops.

Sowing in drills is practised more seldom than broadcast sowing; but it is desirable where the expense of the seed is a consideration. It is important that the drills be of uniform depth. They are best made by means of the so-called "Bavarian sowing-board." This consists of a deal plank, five to six feet long, and about one to two feet broad; on the under side of this, lengthways, three parallel strips of wood are nailed (see Fig. 1). One such board is placed on the bed; the workman then stands upon it, and, by his weight, presses the strips of wood into the soil. Two boards are necessary, so that while standing on one, the workman may place the other in position. The size of the strips, and their distance from one another, will depend upon the depth of sowing required for each species. Other methods are used for making the drills, but the above is as simple and effectual as any.

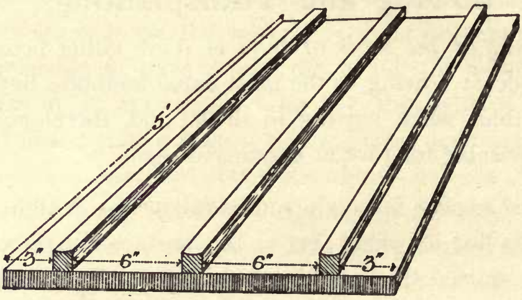

Fig. 1.
Bavarian sowing-board (shown upside down).

Dressing the seeds before sowing is generally advisable, in order to protect them from the attacks of birds, mice, etc. In the case of conifers, it is most essential. This can be done very conveniently by mixing the seeds with red lead to which sufficient water has been added to make it adhere to the seeds.

The collection of seeds is such a specialised process that it is scarcely to be recommended; it is cheaper to purchase them. Conifer seeds need a special method of drying in order to open out the scales. The majority of the broad-leaved trees present less difficulty, as the larger seeds may be picked up after falling to the ground, merely storing them during the winter ; or, as in the case of the ash, the "keys" may be cut off in bunches when ripe, though with this species there is usually no difficulty in obtaining a sufficient number of self-sown seedlings in the woods.

One advantage of the private collection of seeds for estate nurseries is that the seed may be taken from well-grown, middle-aged trees, which have just completed their height-growth, and from which alone the best class of seed can be obtained. The seed produced by too young a tree is characterised by its large size ; that of trees too old, by its small size. Both are unsatisfactory in their germinating capacity and in the vigour of the embryo.

Where seed is gathered privately, too much attention cannot be given to the condition of the trees from which it is taken. When an excessive crop is produced, the seed should be regarded with suspicion ; and this is especially true of the larch, for this tree gives a superabundant crop of seed as soon as attacked by the larch canker. Conifer seed is less affected by the age of the parent than is that of the broad-leaved species.

Spring is *the best time for sowing* the seeds of most species of trees. Under natural conditions, seed ripens in the autumn and usually lies dormant in the ground until spring, large quantities being destroyed by birds and animals during the winter. An exception to this is the elm, the seed of which ripens in June and loses its germinating power unless sown within a short time.

The following are the *quantities of seed per* 100 *square feet* of seed bed which give satisfactory results with a sample of average germinating capacity. Details of nursery work are sometimes expressed in tabular form, but the results obtained in practice vary so enormously that they are apt to be misleading.

Scotch Pine and Spruce	9 oz.	of seed	per 100	square feet.
Larch	1 lb.	,,	,,	,,
Ash	12 oz.	,,	,,	,,
Sycamore	13 oz.	,,	,,	,,
Alder	1 lb.	,,	,,	,,

Speaking generally, a too thick sowing results in a proportionate decrease in the number of seedlings obtained.

The time left in the seed bed will also vary according to the season (whether favourable or not), the thickness of the plants obtained, and the species. For most conifers, two years is the common rule, although they are sometimes moved at one year.

The distance apart of the transplant lines will also vary, as will the number of plants planted per yard lineal.

As the proprietor is not growing for sale, he is advised to allow too much room rather than too little, as a stronger plant is obtained.

Conifers, except larch, require less room than broad-leaved trees, and may be placed in lines nine to ten inches apart, and twelve to sixteen plants per yard; larch and broad-leaved trees, ten inches between the lines, and nine to twelve plants to the yard.

Weeding the seed bed is a very necessary operation in the earlier stages of the seedlings; it must be done carefully at intervals during the summer. The number of times it is necessary to do this during the season will depend on the weather and on the soil. If the sowing is too thick, it is advisable to cut off the superfluous plants close to the ground rather than to pull them out, otherwise the roots of the other seedlings might be disturbed by their removal.

It is sometimes advisable, in broadcast sowing, when the seedlings are too close together, to lift about half of them. This is done in alternate strips about six inches wide, so as to leave undisturbed strips of seedlings of about the same width. The object of this is to supply an increased amount of light and air to the seedlings remaining in the bed.

On most soils in this country *watering* is not often necessary; when imperative, the ground should be well soaked, as, in times of drought, a superficial sprinkling does more harm than good.

Frost-lifting sometimes causes great loss among seedlings. It is caused by alternate freezing and thawing of the surface of the ground, which results in what is commonly termed "throwing the seedlings out of the ground." It is specially dangerous in early spring, on account of the rapid alternations of frost and thaw which often prevail at that period.

Some species are far more liable to frost-lifting than others, particularly spruce and silver fir; whereas sweet chestnut, and other species which develop deep roots soon after germination, are practically immune. The main preventive measures against this danger in the seed bed are, firstly, to sow fairly thickly, and secondly, not to weed in the late autumn, as this loosens the surface of the ground.

Some species, *e.g.*, silver fir, are subject to frost when young, and these are best grown in alternate lines with transplants of some evergreen frost-hardy species, *e.g.*, spruce.

Messrs. Dickson, of Chester, have kindly furnished the details in the following table:—

Species.	Amount of seed.	Number of seedlings expected for 1 lb. seed.	Time left in seed bed. Years.	Distance between transplanted lines.	Distance between plants.
Scotch Pine -	1 lb.	10,000	1 and 2	14 in.	12 plants to 1 yard.
Austrian Pine -	1 lb.	9,800	1 and 2	14 in.	,,
Silver Fir -	1 lb.	1,310	2	14 in.	,,
Spruce - -	1 lb.	21,500	2	14 in.	,,
Larch - -	1 lb.	1,242	1 and 2	14 in.	,,
Beech - -	1 lb.	194	1	14 in.	,,
Ash - -	1 lb.	380	1	14 in.	,,
Sycamore -	1 lb.	240	1	14 in.	,,
Alder - -	1 lb.	7,000	1	14 in.	,,

The transplant is the term applied to the seedling on its first removal. The seedling is lifted at an age of one to three years, and is transplanted again in the nursery. The effect of this is twofold: it gives an increased growing area to the plant; also it ensures a compact root-system, and it stimulates the production of fibrous roots.

Transplanting should take place in early spring, and this is especially advisable in the case of conifers. Broad-leaved tree seedlings may be moved during the time between the ripening of the year's growth in autumn and the swelling of the buds in spring; but early spring is preferable in all cases. Where a tap-root has developed, it should be shortened before planting.

When transplanting, a trench is dug, with one side vertical. This is indeed very important; for, although it is less convenient to make the first insertion of the spade vertically, yet unless this is done the axis of root and stem will grow at an angle. The result will be that the final planting will be more difficult, and the tree will show the defect for years after planting (see Fig. 5, p. 23). Generally speaking, conifers take longer to recover from this defect than do the broad-leaved species.

The depth of the trench will vary according to the size of the roots; for the depth to which the plants are inserted, should be nearly as possible the same as that at which they originally stood —as indicated by the earth mark on their stems. The seedlings are placed on the vertical side of the trench, and the soil is filled in and pressed down very firmly with the foot. The distance between the plants and between the rows, will vary according to species, size of plants, and the time they are intended to remain in the lines. The figures in the table (p. 13) may be taken as most advisable under ordinary conditions. As a rule, transplanting at intervals of two years is advisable; as, if moved more often than this, a needless disturbance of the root-system takes place, if at longer periods, the compactness of the root-system is damaged.

The lines of transplants will merely require to be kept free from weeds. Especial care should be taken in weeding larch, as wounds in the bark afford access to the spores of canker.

The lifting of the transplants, for planting out, should be done with as little disturbance of the root-system as possible. The four-pronged fork is the tool usually employed, and the best method is for two men to insert their forks, simultaneously, at opposite sides of the row.

If there is much discrepancy in the size of the transplants on lifting, it is advisable to grade them into two lots. The smaller plants should be lined out in the nursery once more; or else they should be used for those areas where the surface vegetation is less strong, so that they may not be overgrown by weeds.

Where *large plants* are required for ornamental planting, etc., the transplants should be replanted, at intervals of two or three years, in order to obtain a compact root-system capable of being planted out finally with the least possible check to its growth.

Vegetative Reproduction.

Vegetative reproduction. Usually our forest trees are reproduced by means of seeds. In some cases, however, it is more convenient, or even imperative, to employ a portion of the vegetative organs of the parent plant. The methods commonly used in the forest nursery are those of setting "layers" or "cuttings."

Layers are employed for the propagation of limes, elms, etc. For a species to be layered successfully, it must be able to produce stool-shoots, and also adventitious roots. In forestry, the practice is limited to those species whose seeds germinate unsatisfactorily.

A sufficient number of young plants are procured and established in a convenient spot in the nursery. When well established, they are cut down to within a few inches of the ground ; the cut should be slanting in order that the rain may run off the cut surface. Four- or five-year-old plants are the most satisfactory, and the *end* of winter is the best time for the operation on account of its effect on the sap.

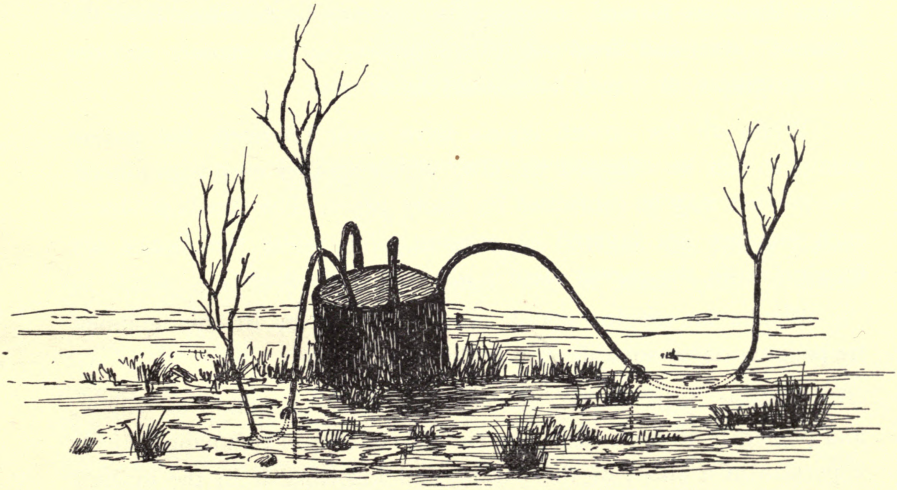

Fig. 2.

Stump with "stool-shoots" ; two of which are pegged down. The cut should be more slanting than that indicated in the figure (see text above).

Shoots—termed "stool-shoots"—are then formed round the cut edge of the stump, Fig. 2; when about one year old these are bent down and pegged securely to the ground. The bark is partially "ringed" or "tongued" on the lower side of the shoot, as shown in Fig. 3; and this portion is covered with soil to the depth of four or five inches. A little sharp grit or sand placed against the wounded surface is useful in stimulating the formation of the adventitious roots. When these are formed, the rooted shoot may be detached from the "parent" stem and lined out in the nursery in the manner adopted for transplants, or it may be planted out at once.

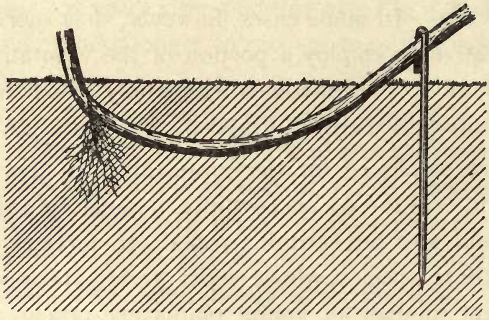

Fig. 3.
"Stool-shoot," pegged down, showing the cut and the young roots growing from it.

When all the rooted layers have been removed, the parent stump should be trimmed up, after which another crop is produced. The process may be continued for many years. The shoots produced each summer are layered in autumn, and, while the layers are forming roots, the parent stool is growing fresh shoots.

Blanks in coppice woods may be filled in, in this manner, by pegging down suitable young shoots.

Cuttings, Slips or Sets are used in the propagation of willows and poplars. In both cases, the method consists of removing entirely a portion of a shoot of the parent, and inserting it in the ground. Mature timber is produced more quickly by this method than from seeds.

The length of the cuttings or slips may be from a few inches, up to eight or nine feet. The cutting may consist of the entire shoot, or one which has been truncated. In the latter case, it is important that the top of the shoot is removed with a clean slanting cut, so that rain may not lodge on it. Cuttings are usually planted in the place in which it is intended they should grow. Of course, each cutting must have at least one young bud on it, usually several.

The only points to note in the planting of cuttings are :—

(*a*) They should be firmly planted.

(*b*) The bark should not be disturbed at the inserted end.

(*c*) The cut should be made just below a bud.

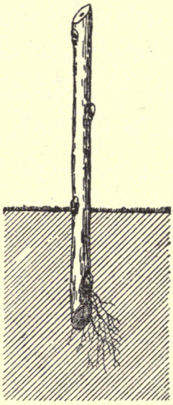

Fig. 4.
A "cutting" showing the slanting cuts, and the rootlets growing from a bud.

Rotation. There are many dangers to which the young plants are liable, due to insects and fungi, and in many cases a given species of insect or fungus is only dangerous to one species of tree. Moreover, conifers and broad-leaved trees make somewhat different demands on the soil. It will be evident at once, therefore, that it is highly important, whenever possible, to follow a crop of a broad-leaved species by a crop of conifers, or vice versa, as by this method the pests are starved.

CHAPTER III

ESTABLISHMENT OF WOODS

THOUGH it is not always possible, nor is it entirely desirable, to make elaborate preparations for the final planting of the young tree from the nursery, yet some preliminary treatment of the ground is usually necessary.

Preparation of the site. Though little or no actual cultivation of the ground is necessary, it is most important that the natural herbage of the ground should be kept in check. This is a point to which, as a rule, far too little attention is given.

Usually the young tree is removed from the nursery where it has received care and attention ; it is planted out amongst a rank growth of weeds ; and it is expected to contend with them. As a result, the young trees are weakened, and the subsequent cleaning is usually a more expensive operation than if the site had been properly cleaned beforehand, and had been weeded during the earlier stages of the seedling's growth. Not only does it cost more, but the trees are weakened and therefore are more subject to disease[1] if attention is not paid to the ground before planting out.

Weeds.

Weeds are chiefly troublesome in the earlier stages of a wood, although in pure woods of light-demanding species, twining plants, such as honeysuckle, etc., may be troublesome at a later stage. The slower the growth when young, the greater is the danger of the trees being overgrown and suppressed by the weeds.

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[1] This accounts for many of the failures to make forestry pay. In one instance, the author visited an estate where insufficient attention had been given to this. It cost £5 per acre to clean the land, and then the trees already had been very much weakened. How can forestry pay under such conditions ?

Weeds are injurious in five ways:—

(1) By overgrowing the plantation and shutting out light and air; *e.g.*, bramble.

(2) By the ramification of their roots in the soil, by which the nourishment of the tree is intercepted; *e.g.*, grasses generally.

(3) By overlying the young plants in the winter and pressing them down with their rotting stems; *e.g.*, bracken.

(4) By constriction of the stem of the tree; *e.g.*, honeysuckle.

(5) By harbouring injurious insects and fungi.

Weeds on fertile soils. Fertile soils are particularly productive of weeds, and possibly the bramble is the most dangerous, troublesome, and expensive to get rid of. Cutting it down and bruising the young shoots until the forest canopy is formed is almost the only resource available. Cutting alone merely increases its vigour. Large planting operations, however, are seldom conducted on this class of soil.

Grass is sure to be present, forming a more or less dense growth. It is, however, usually sufficient to press it away from around the young trees with the foot twice a year. In some cases it may pay to cut the grass for fodder, of course bearing in mind the damage which the young trees may suffer from an inadvertent wound.

Weeds on marshy soil. Typical weeds indigenous to this class of soil are the various species of bulrushes, sedges, and rushes. Drainage is an effectual remedy.

Poplars, willows, and alders are the trees usually grown on this class of soil, and, being of rapid growth, soon get clear of the weeds.

Weeds on rough upland pastures. The most familiar weeds on this class of land are seedling birch, heather, gorse, broom, and bracken, all of which are characteristic of rough mountain pasture. Speaking generally, gorse and broom indicate a slightly better class of soil than that on which bracken and heather flourish.

The shoots of the self-sown birch tree are a very serious pest on this class of land. Whilst upland pasture is being grazed by sheep, numerous small birch trees are eaten down ; but when the area is enclosed for planting, these young plants grow up and form a serious menace to the trees which it is intended to grow. In some cases, a *moderate growth* of birch may be rather beneficial, the plants acting as nurses for the species planted, as, under such conditions, they are so "storm-firm." For, though the birch is *not* a storm-firm species, yet, owing to continual grazing off, its root-system becomes so much developed as to make it storm-firm in this case. Where self-sown birch interferes with the species planted, an effectual remedy is to cut through the bark at the base of the stem, the cut forming a complete ring.

All woody plants are best destroyed by cutting down in *July*, at a short distance from the ground, it being most probable that the stump will rot away. The more injurious "jungle" will be dealt with in some detail, as it is seldom that planting can be done without having to take into consideration at least one form of it.

Ling and heather, when growing luxuriantly, are sure signs of a poor soil. Heather is injurious in two ways: firstly, by yielding a particular kind of humus from its rotting shoots and leaves, which seems to have an injurious effect on vegetation (Scotch pine, birch, and aspen seem, however, to be immune from its effect) ; secondly, by restricting the roots and crowns of the young trees.

The best method of clearing the ground of heather is by burning or cutting. By the time the heather has grown up again, the trees will be very much taller.

Gorse and broom commonly grow on rather deep sandy soils, attaining a height of four feet or more. Uprooting is sometimes advisable, but it is usually sufficient if it is burnt, or cut down to about eight inches from the ground. This should be done in *July*, and before the seeds have formed. Usually, the plant shoots up again, and it would be best to keep the new growth down as low as possible by cutting. Where game is preserved, however, this young growth may be desired ; and in such a case, though not advisable, it may be allowed to grow sufficiently for the game, provided that it is kept within bounds. The danger is that the gorse may form a harbourage for rabbits and mice, which would bark the trees and kill them. If the growth of the gorse or broom is kept down, the trees will soon grow up, form a canopy, and kill it off or weaken it.

Bracken. The young shoots may be broken off as they appear above ground ; cutting the plants with a scythe has the advantage that the stems may be used for litter, and if this cutting is done two or three times in the growing season, while the stems are green, the plants are effectually weakened.

Where possible, a chain harrow is useful in bruising the young fronds. This, of course, can be used only before planting.

Drainage.

Drainage. Drainage is an important operation in agriculture ; but it is very doubtful if it pays to go to much expense in draining land which is to be planted with trees ; at any rate, it would be well to consider the cost before commencing. Whenever a wet place occurs in an area which it is proposed to plant, it is often thought essential to cut drains in all directions ; whereas, in many cases, it would be far more profitable to plant trees which are capable of thriving on a swampy site, such as birch, Scotch pine, etc. Many comprehensive works have been written on drainage, and the reader is referred to these for general information on the subject.[1]

The *advantages of drainage* from the forester's point of view are:

(1) Land previously unfit for planting (except in the case of a few species) is made capable of growing the more valuable trees.

(2) The "Annual Increment" of timber (see p. 3) is increased by the greater depth of the feeding area available for the roots.

(3) The manurial ingredients are more available, owing to the increased aeration of the soil.

(4) The normal health of the trees is increased, so that there is less chance of damage from fungi and insects.

(5) Trees are less liable to be blown down, owing to their deeper roots.

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[1] Mitchell, A., "A Handbook of Land Drainage." Published by the Land Agent's Records, Ltd., 1898.

Having determined upon the advisability of draining an area, the following points should be noted: firstly, that drainage should take place at least a year before the planting operations are begun; and, secondly, that, after planting, the drains should be kept in working order. The reason of this is that the roots are accustomed to a certain feeding area; this is limited by the "water-table"—or the level of the water in the ground—so that it is essential that this "water-table" be maintained at a constant level. A blocked drain will raise the "water-table" immediately, so that the roots will be submerged and their feeding power impaired; on the removal of the obstruction, the "water-table" is lowered, and, if a very dry summer ensues, it is most probable that the annual ring deposited will be smaller.

Open drains are, of course, the only forms adopted. The distance apart may be from thirty to sixty feet, according to the nature of the soil.

Planting.

Planting. The soil of the site on which planting is carried out will vary. It may be a deep loamy soil with a natural growth of grasses and weeds—sometimes termed "jungle"—which may attain a height of two feet or more; or it may be a shallow stony soil with a natural growth of short herbage or turf; on the other hand, it may be dry, or boggy; or it may be some combination of these.

It will be evident that the same methods of planting are not suitable for all classes of land, and that the method must be adapted to the soil. In deep soil, if a small plant is used, either it will be suppressed by the "jungle," or else needless expense will be incurred in keeping the small trees clear. In a shallow soil, a large plant would be at the mercy of the wind before the roots were established and also there would be great difficulty and expense in making holes of sufficient size to accommodate the roots of a large plant.

There are two methods of planting commonly practised in this country—"pit planting," and "notching" or "slitting"—each being suited for a particular class of ground.

Pit planting is the method adopted for planting in those soils where "jungle" is of luxuriant growth and where large plants are necessary.

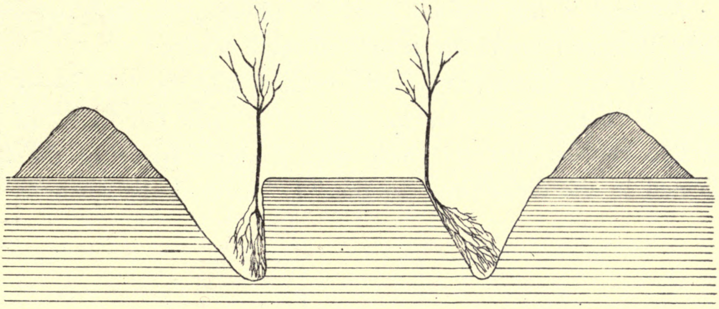

Fig. 5.

The right and wrong way to insert a transplant. On the right, the roots are on one side and the stem is bent. They should be planted as shown on the left.

A hole is dug of a size suitable to the roots. The material removed is set aside in two portions—the top part and the bottom part. The plant is then held in such a manner that *the roots assume a natural position;*[1] the soil taken from the *top* is filled in round the roots, the remaining soil taken from the *bottom* is placed on top. The whole is then made firm with the foot. Before the pit is completely filled, and before the soil is made firm, it is advisable to raise the plant slightly; this gives the roots a natural position and a more intimate contact with the soil. It is important to note that the plant is at the same depth as it was when growing in the nursery lines.

In clay soils, it is advisable to dig the pits in autumn, in order that the soil forming the sides of the pit, and also the soil removed in digging it, may be exposed to the influence of frost, etc. This "weathers" the soil and renders it more friable, so that the plant food is more readily available. But it cannot be done in localities where water is likely to stand in the holes.

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[1] It has been suggested recently that it is even more advantageous to plant *fruit* trees "anyhow," by placing their roots in the hole in any position, covering with soil and tramping down. To the author, the method seems to be quite unreasonable, and observations show that it is conducive to the worst results—in *forest* trees.

Where the soil is light and inclined to be dry, the pits should be dug when required, in order that the sides and bottoms may not get too dry, or fall in.

Notching is the method used for planting on soils where the scanty herbage permits the growth of small plants.

There are variations in this method, and the two forms most commonly in vogue are known as the "L" and the "T." In each case two vertical slits are made with a sharp spade in the forms indicated in the diagrams. In the "L" method the spade is used as a lever to raise the turf in the second cut, and the plant is inserted in the angle of the exposed cuts. In each case the position of the plant is shown by the asterisk (Fig. 6). The young plant is placed in the angle of the slits, at the same depth as it stood formerly, and all is made firm by pressing back the turf with the foot.

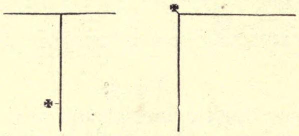

Fig. 6.
The T and L method of "notching."

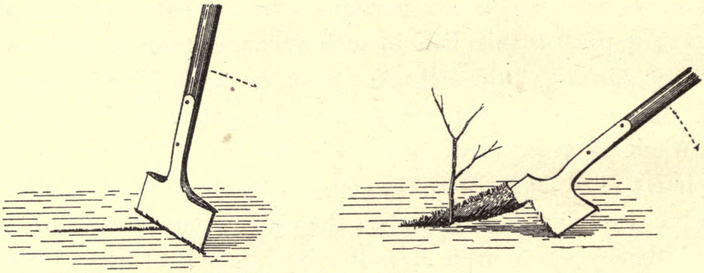

Fig. 7.
"Notching" by the T method, showing manner of inserting the transplant.

This method is the cheapest of any, but there is the drawback that the roots are in a cramped and unnatural position, and it can only be used for small plants on light soils.

The distance between the plants is important. Close planting is necessary for the production of "clean" timber, and to ensure that the ground is shaded by a canopy of sufficient density as soon as possible (see p. 33). The exact distance will be governed by the fertility of the soil, the size of the plants, the shade-bearing capacity of the species chosen, the method of planting, etc. To give minute details for the planting of each species would occupy too much space. A general rule, which will apply to every case without entailing much error, will be to place the plants three feet apart—that is, at the rate of 4,840 per acre.

Pit planting is never done at a distance less than three feet from plant to plant—that is, at the rate of 4,840 to the acre. In the case of natural regeneration (see p. 27), however, as many as 50,000 to 100,000 seedlings may be found on an acre; these, after a comparatively short space of time, are reduced to a limited number, the strongest plants taking the lead and suppressing those which are physically unfit.

The expense of the planting is an important consideration. On the one hand, close planting entails a greater initial expense; but this extra outlay is more than repaid by the greatly increased value of the timber produced. On the other hand, placing the plants too far apart produces coarse, unclean timber, of comparatively small commercial value; and it is this which has led to the low price of certain English timbers, especially that from conifers.

In the present state of British forestry, close planting, even though additional expense be incurred, cannot be too strongly insisted upon. The matter is, of course, entirely different where ornamental effect only is the end in view.

When a steep gradient has to be planted, the *horizontal distance* from plant to plant should be taken.

To find the number of plants required to plant an acre of ground, *multiply* the number of acres by 4,840; *divide* by the distance between the plants (in yards), multiplied by itself. Thus, to plant two acres of ground with plants arranged in squares at three feet or one yard apart, 9,680 plants will be required. By the same rule it will be found that if the plants are arranged at four feet

($1\frac{1}{3}$ yards), only 5,469 plants will be required, or little more than half the former amount.

Planting on boggy soils. The methods adopted in this country, almost universally, are pit planting and notching, but special methods are sometimes required to meet special circumstances. A Belgian system is adapted for planting moorlands; by this method, woods can be established upon land which is otherwise unprofitable; an unremunerative waste can be made to return a good rental; and a profit can be obtained which is only little inferior to that which would be derived from reasonably good arable land. For this reason a brief summary of the method is given; further information may be gained from a paper by Sir John Stirling Maxwell,[1] from which the following notes are taken.

The system is advocated for marshy hollows in the Highlands of Scotland, where the trees have to be planted on almost pure peat. This class of soil is so retentive of moisture that *ordinary* draining is of little use, unless the drains are so close together that the expense is prohibitive. In the system referred to, the planting is done at a distance of four feet. Drains are cut twelve feet apart, allowing three rows of plants between them. The drains themselves are two feet wide at the top, fifteen inches wide at the bottom, and ten inches deep.

In cutting the drains, the top spit is cut out in twenty-inch lengths; each turf is placed bottom upwards in positions as shown in the plan. This size of turf, and the distance between the drains, allows the turfs to be placed four feet apart. They are left to dry for a year, during which time they will shrink considerably. Then a hole is made in the centre of the turf (by a Belgian planting tool) and the plant is inserted. By placing the turfs upside down in this manner, the depth of the surface soil is practically doubled. This double thickness of soil, and the closeness of the drains, enables the young plant to get a good start, and to become thoroughly established. Two-year-old Scotch pine seedling would probably be the best for the purpose.

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[1] "Belgian System of Planting on Turfs." Trans. Roy. Scot. Arboricultural Soc.

Natural Regeneration.

Natural regeneration. This process has been responsible for the origin and establishment of our historic woods. It consists of the germination and subsequent development of the seeds and fruits which fall to the ground from the parent trees. The subject is very intricate, and requires expert knowledge and experience to be used to the best advantage. Nevertheless, a few notes may be of use to the owner or manager of an estate.

The main crop of timber should have reached maturity and be ready for felling. Under good management, the canopy should be too dense to allow the young plants to grow; and in such a case, trees must be felled to admit sufficient air and light.

The condition of the layer of litter under the trees, consisting of dead leaves, twigs, etc., is an important consideration. The thickness of this litter will depend upon the species of tree composing the wood, if pure; or, in the case of a mixed wood, on the number of shade-demanding trees present (see p. 40). This layer may be too deep for the young seedlings; for, unless the root of the young plant can penetrate to the soil proper within a few weeks of its germination, it is unable to obtain the necessary manurial food constituents, and it ceases to thrive. If the layer of humus is of too great a depth, it can easily be reduced by thinning. The increased amount of light and air admitted to the soil quickly reduces its volume by decomposition; moreover, without this decomposition, the humus is not in a condition suitable for the proper growth of the plant. The rate of decomposition varies with the species of tree from which the litter is obtained.

The amount of light admitted to the ground should vary with different species of trees, and with the soils upon which they are planted. The felling must be done with due regard to the requirements of the case. Besides the alteration in the condition of the humus resulting from it, an increased vitality is given to the remaining trees, inducing the production of seed, provided that the operation is carried out with care.

Felling must not be too severe, as a sufficient number of trees must be left to form "shelter wood," until the young trees have become established. This "shelter wood" should be composed of well shaped, healthy trees only, as evenly distributed over the area as possible.

If a good seed year does not follow the felling, it is advisable to augment the number of young plants—which under these circumstances will be small—by the collection and sowing of seeds from other woods, for, unless the young trees are sufficiently close, weeds may spring up and prevent the growth of plants from subsequent seed crops.

CHAPTER IV

CONDITIONS AFFECTING GROWTH

THE conditions which affect growth are very numerous. In the following account, only those subjects are dealt with which are of primary importance to the management of estate-woods.

Species and soils. It is not within the scope of the present volume to enter upon a description of soils; it must suffice to indicate the relation of species of tree to soil. As a rule, it is the land with which the farmer can do little or nothing that requires afforestation. The most important point to decide before planting the ground, is the kinds of trees which are likely to thrive on that particular soil. Any attempt to establish a species in a locality not suited to it, is bound to fail.

In this volume, the term "soil" also includes the subsoil, or rather so much of the subsoil as is capable of being penetrated by the roots of the trees.

The geological formation is of great importance. In the "Assessment of a Locality," however, there are many considerations, other than this, which have to be taken into account. The chief of these—which alone need be considered here—are depth and moisture.

(1) *Geological formation.* The following species will grow on the soils enumerated:—

Calcareous Soils

Acacia
Alder
Aspen
Beech
Horse Chestnut
Sweet Chestnut
Sycamore
Norway Maple
Austrian Pine
Corsican Pine
Scotch Pine
Cedar of Lebanon

Calcareous Soils—continued

Wych Elm
Hornbeam
Lime
White Poplar
Canadian Poplar
Deodar
European Larch
Japanese Larch
Lawson's Cypress
Spruce

Clay

Hornbeam
Sweet Chestnut
Pedunculate Oak
Sessile Oak
Chestnut
Thuja gigantea

Gravel or Sand

Birch
Hornbeam
Beech
Ash
Walnut
Scotch Pine
Austrian Pine
Corsican Pine
Yew
Oriental Plane
False Acacia
Oak
English Elm
Wych Elm
Lime

Drained Peat

Alders (generally)
Birch
Beech
Bird Cherry
Elm
Lime
White Poplar
Canadian Poplar
Crack Willow
Norway Spruce
Black Spruce
Sitka Spruce
Scotch Pine
Austrian Pine
Corsican Pine
Larch
Deodar
Lawson's Cypress

(2) *Depth.* By "depth," is meant the depth of the soil which is capable of being penetrated by the roots. According to Hesse (p. 6), the following species are content with the depth of soil indicated. Of course, other conditions being suitable, all species will flourish on deep soils; and, when this is the case, the greater the depth to which the roots penetrate, the greater the height-growth.

Shallow Soils

Spruce
Birch
Aspen
Mountain Pine
Rowan

Soils of moderate depth

Austrian Pine
Weymouth Pine
Beech
Hornbeam
Black Poplar
Tree Willows
Alder
Horse Chestnut

Soils of greater depth

Scotch Pine
Cambrian Pine
Common Elm
Wych Elm
Norway Maple
Sycamore
White Poplar

Deep Soils

Silver Fir
Larch
Ash
Lime
Sweet Chestnut
Oak of all kinds

(3) *Moisture.* According to Schlich (p. 7), the following classification of the requirements of the following species holds good.

Wet Soils

Common Alder
Ash
Poplars (most species)
Willows (most species)

Moist Soils

Cambrian Pine
Hornbeam
Elm
Lime
Mountain Ash
Pedunculate Oak

Fresh Soils

Silver Fir
Spruce
Larch
Beech
Sessile Oak
Norway Maple
Sycamore
Weymouth Pine
Sweet Chestnut

Dry Soils

Corsican Pine
Scotch Pine
Austrian Pine
Birch
Acacia
Aspen

Speaking generally, pine, birch, poplar, and rowan are probably the least dependent on good soils; whereas oak, ash, elm, and sycamore require them.

Trees remove an almost insignificant amount of mineral matter from the ground compared with the ordinary agricultural crop. This is shown by the following extracts from a table as given by Ebermayer (p. 8).

	Ash.	K_2O.	CaO.	MgO.	P_2O_5.	SO_3.	SiO_2.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Wheat ...	186	28	14	9	21	4	100
Clover ...	303	98	107	29	36	11	9
Potatoes ...	231	107	36	18	32	14	8
Beech ... ... (Wood only)	27	5	13	3·7	2·3	0·3	2·7
Scotch Pine ... (Wood only)	13	2	8	1	0·9	0·2	0·4

The above results are taken from calculations based on the timber only; the leaves use a larger quantity of minerals.

Beech ... (Wood and leaves)	194	13	89	15	12	4	56
Scotch Pine ... (Wood and leaves)	52	6	24	5	4	2	6

Further details of the requirements of different species of trees are given in Chapter VII.

Light-demanding and shade-bearing trees. In some trees, the side branches are killed off by shading at an early age, and, at the same time, the crown opens out. Consequently, there is not sufficient shade on the soil ; so that grass and weeds grow up, the accumulation of humus is lessened, and the grass intercepts the rainfall and utilises the available water. Such trees are termed "light-demanding" trees. Towards the end of a long rotation of such trees, the annual increment—that is, the amount of wood produced per acre per annum—is not maintained, owing to the decrease of fertility in the soil. Such are oak, ash, larch.

In other trees, there is a thick canopy which shades the soil, so that grass and weeds cannot grow up, and humus accumulates. Such trees are termed "shade-bearing," and in these, even towards the end of the rotation, the annual increment is maintained, owing to the upkeep of soil fertility. Such are beech and spruce.

This difference between light-demanding and shade-bearing trees must be considered in most questions of forestry, more especially in relation to thinning and to mixed woods (see pp. 34 and 40).

Canopy. The growth of the individual trees composing a wood tends to cause the meeting and subsequent interlacing of the branches. These interlacing branches form what is known as the "canopy," and as complete a canopy as possible should be obtained as soon as circumstances will permit.

The *density of the canopy* will depend upon the capacity of the species for bearing shade. If this quality is possessed, and a thick shade over the tree-stems and soil is obtained, then the most favourable conditions of growth are realised.

A light-demanding species is unable to form a satisfactory canopy ; for, at a comparatively early age, the crowns thin out, and too much air and light are admitted to the surface of the ground. These species, however, parting with their lateral branches more freely, produce cleaner timber with less shade.

It will be evident at once that *upon the proper regulation of the canopy depends the quantity and quality of the timber produced.*

The influence of the canopy on the quality of the timber is dealt with, under *Thinning*, below. Too dense a shade will produce tall, drawn-up trees lacking in diameter, of a weakly nature, and liable to fungoid and insect attacks; on the other hand, if too thin, the timber produced will be rough and knotty.

The influence of the canopy upon the soil is seldom sufficiently considered. A dense canopy kills off all surface vegetation, and the leaf-fall, being protected from sun and wind, forms a layer of slowly decomposing vegetable matter. The importance of this cannot be over-estimated. Poor soils planted with shade-bearing trees are improved in their fertility, so that at the final cutting the ground is left in better condition than when first planted.

In a wood of light-demanding trees only, the canopy is thin and the leaf-fall is exposed to light and air, the layer of humus is quickly decomposed, and moisture is not conserved. The consequence is that the ground is covered with a surface vegetation composed of grass and weeds.

Thinning. It is necessary to plant the trees close together, in the first place, in order that the lateral branches of the young trees may be killed off by the shade afforded by the canopy, as early as possible. The presence of a branch means the presence of a knot (see Figs. 8 and 9); a dead branch forms a loose knot which will fall out when the timber is sawn up into planks.[1] But as the young trees grow, some of them must be removed in order to allow an increased growing area for the remainder.

The period at which thinning will be commenced will depend upon a variety of circumstances; the more important of these are the distance apart at which the trees are planted, and the species of tree. The closer the trees are planted, the sooner must thinning commence. The first thinning must be done sooner in the case of a light-demanding species than would be necessary, or even advisable, in the case of a shade-bearing kind of tree.

The first thinning will probably consist of dead or weakly specimens; also, there may be some undesirable species of tree which have grown from self-sown seed and which require to be removed. Birch on hill pastures is especially troublesome in this respect.

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[1] This is an important consideration, and the neglect of it has gained a bad reputation for our home-grown timber.

When an area is planted, say, with saplings at three feet apart, the trees will grow for some years without interfering with each other; gradually, however, the increasing size of the trees causes an increase in the struggle to obtain light and air. In this struggle, the stronger specimens, having obtained a greater height-growth than the weaker ones, obtain the greatest benefit from the sun and air; so that the weaker trees are gradually overshadowed and suppressed. For the same reason, the side branches of all the trees will die off, near the ground. This is termed natural pruning, or, as is commonly said, "the trees have begun to clean themselves."

Effect of thinning. Where thinning has been delayed, the trees are "drawn up." The stems are straight and tall, and the girth tends to be the same at the top as it is at the bottom—in other words, the trees "carry their girth well." These features are excellent, of course; but if thinning is delayed too long, the timber is less durable, the health of the trees suffers, and they are more liable to fungoid and insect attacks.

The presence of a branch means the presence of a knot, which will increase in size each year, as long as the branch remains on the tree. Hence the importance of planting a wood sufficiently close, so that the lower lateral branches may be killed at as early a date as possible. Timber is required to be clean, free from knots, and with even-sized rings throughout.

In dense woods, the annual ring (see p. 44) is small and decreases as the canopy becomes more dense. A thinning can usually be traced in a transverse section of a tree-stem by an increased width of the rings formed after the operation.

An isolated tree is characterised by larger diameter, smaller height, thicker and rougher bark; the timber is more full of large knots than if grown in a dense wood; and, moreover, the crown, spreading over a larger area, will produce a larger amount of inferior wood.

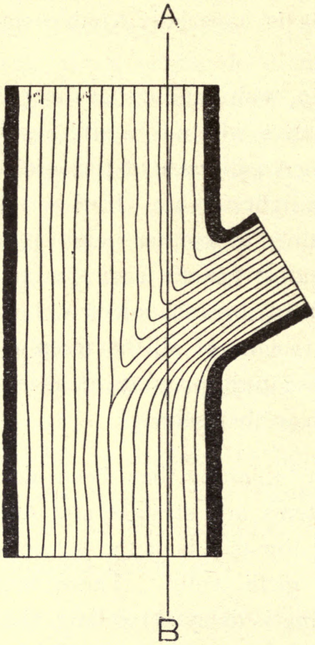

Fig. 8.
Diagram of a trunk with a branch.

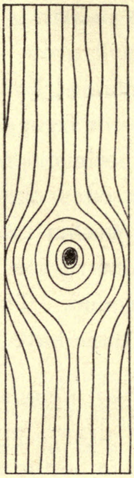

Fig. 9.
A board cut from the tree in Fig. 8, cut along the line AB, showing the knot.

A good height-growth, a restricted crown with few large branches, and a clean cylindrical stem, are characteristic of trees growing in a dense wood. This type, therefore, furnishes the greatest amount of valuable timber.

The object of thinning is to regulate the growing space of each tree—"the room it has to grow in," to use an ordinary expression—in order that the largest possible amount of high quality timber may be produced per acre each year.

It is hardly possible to give figures regarding the number of trees to be removed in the thinnings at given periods, as these will vary according to the fertility of the soil, and to the suitability to the locality of the species planted. This is one of the details where the advice of an expert should be taken; he, having made an "assessment of the locality," will be able to take into account all the many points requiring consideration.[1]

In mixed woods (see p. 40), the first thinning may consist of (1) such species as may have been used as a "nurse" for the temporary shelter and protection of a more valuable species, provided that the latter is sufficiently well established to fight its own battle; (2) single specimens which have become attacked by disease, or which are weaker; (3) species which are found to be unsuited to the district.

The following statistics, collected in Germany, apply only to soils of the first quality.[2]

Age of wood in years.	Number of trees per acre.		Trees removed *per annum* per acre.	
	SCOTCH PINE.	SPRUCE.	SCOTCH PINE.	SPRUCE.
20	2,970	1,420	—	—
40	1,130	720	92	35
60	510	370	31	17½
80	310	230	10	7
100	220	170	4½	3

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[1] *It is due to reckless overthinning* in the past that British timber has got such a bad name for roughness, more especially as regards pine and spruce. Years of care and good work may be spoilt by insufficient attention to this, with a consequent loss of "profit" to the landowner.

[2] Schlich's "Manual of Forestry," vol. 2, p. 290.

CHAPTER V

METHODS OF SYLVICULTURE

THERE are recognised methods for obtaining the largest production of timber from a given area, in any locality. Where a wood is established by planting or sowing each individual tree, so that each tree may grow to full maturity and be felled, such a forest or wood is termed a *high forest;* in other words, a *high forest* is a wood in which each individual tree of the main crop is allowed to attain its maximum development before felling.

Where, on the other hand, the wood is regenerated by the growth of stool-shoots from the parent stump, the wood is termed a *coppice.*[1]

Each of these systems is adapted to different purposes, and each of them, or some modification or some combination of them, must be selected according to the requirements of the locality. Which system it is most advisable to adopt, will depend upon so many factors, such as soil, climate, local demand for the produce, etc., that an expert knowledge is required to decide. To do more than to indicate the main principles which must be taken into account in arriving at a decision is beyond the scope of this work; for detailed information, one or other of the larger textbooks should be consulted.

The following short notes may be of some assistance to the man who wishes to make use of the outlines of practical forestry.

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[1] "Coppice" is also used as a popular term to designate any small plantation, even though the trees composing it are of a species incapable of producing stool-shoots, such as conifers, etc. So that it will be noted that there is a difference between the meaning of the term "coppice" as used in forestry and as colloquially applied.

Another instance of confusion between scientific and popular terms is the term "light-thinning." This, in forestry, means thinning *to admit light;* in ordinary parlance it would mean the removal of a few trees only.

Under-planting may be usefully practised about the middle of a rotation of light-demanding trees, for the canopy of such trees, at first rather dense, opens out and is unable to shade the ground properly. After thinning, a shade-bearing species is planted where space permits.

The original crop is probably straight and clean, and the thinning allows their stems to increase in diameter. The ground is sheltered and its fertility maintained by the young shade-bearing trees.

The *two-storied system* differs from the above in that a light-demanding and a shade-bearing species are planted at the same time—*e.g.*, oak and beech—both species growing up together. At about the age of fifty years, the beeches are removed and the oak is under-planted with another crop of beech. The oak and the second crop of beech are then felled together. The highest quality of oak timber may be produced in this manner.

It should be remembered that the *principal* species is light-demanding, both in under-planting and in the two-storied system ; a shade-bearer being the subsidiary species. Both systems are useful in the production of high-class oak, ash, larch, etc. Under-planting has the advantage that the principal species cannot be suppressed in the initial stages by the subsidiary trees, as sometimes happens in the two-storied system.

The *method of coppice* is limited to those species producing stool-shoots, and this excludes conifers from the list. Extensive oak coppices formerly existed for the sake of the bark. The effect of coppice woods on the soil is not particularly good, the rotation being short and the soil left exposed at the end of each cutting. Coppice with standards is very common, the standards, of course, being light-demanders. The number of them may be increased by preserving a single specially straight stool-shoot on each stool. This plan, however, has the disadvantage that trees produced in this manner are not so tall as those grown from seed, cuttings or layers.

The conversion of coppice into high woods may be accomplished in this manner, and the success of the operation will depend on the soundness of the stools.

The harvesting of the crop should be done in the most careful manner, as upon this depends the longevity of the stools, and after the cutting, the stools should be trimmed so that water will not lodge. Oak, ash, sweet chestnut, and hazel are suitable species for this method of culture.

Pure and Mixed Woods.

A *pure wood* is a wood composed of one species of tree only. It is rare in practice, or else it shows a bad system of forestry; for, over an extensive area, there is sure to be some variation in the soil, and so the probability is that one species cannot thrive efficiently throughout the whole area. The consequence is that stunted and diseased patches of trees are produced, and these form centres of infection from which attacks by insects and fungi may spread to the healthy portions of the wood. Further, an error in judgment may have been made in the selection of the species for planting. Then, if the wood consists of one species only, the whole is unsatisfactory and is not likely to be remunerative; whereas, if more than one species is planted, the most unsuitable one can be cut out. Pure woods of light-demanding species are permissible, however, when the trees are to be cut at an early age—*e.g.*, pit wood, or when no other species will grow.

Many species are not adapted to form pure woods, owing to the opening out of their crowns at an early age, and to the consequent deterioration of the soil. Again, when the soil is very good, valuable species may be grown pure, although, even then, there is a likelihood of the soil deteriorating towards the end of the rotation.

The term *mixed wood* is applied to a wood composed of two or more species. The advantages are to a great extent analagous to those of rotations in agriculture. They may be summarised as follows:—

(1) Different trees make different demands on the soil; consequently, the soil being fully utilised, a larger amount of timber is produced.

(2) "Frost-tender" species are protected by the more hardy ones.

(3) The mixture of broad-leaved trees with conifers, lessens the danger of "snow-break" of the latter.

(4) "Storm-firm" species shelter the weaker species from wind.

(5) The species may be selected suitable to the varying nature of the soil (see *Mixture by groups*, below).

(6) By admixture with shade-bearers, light-demanding trees may be grown without diminishing the soil fertility, and the annual increment of timber is maintained to the very end of the rotation.

(7) Any species not adapted to the locality, or attacked by insects and fungi, may be removed in the thinnings.

Mixed woods may be formed by planting each species in groups —mixture by groups; or they may be formed by planting according to a definite plan previously decided upon, when single specimens of one species are placed alternately with single specimens of another —mixture by single trees.

(1) *Mixture by groups.*

This is the usual method employed where the conditions of soil, elevation, etc., vary throughout the planting area. The groups may be composed either of one species of tree only, or of two or more species. Each group may be regarded as a small independent wood, the soil on which it is growing being of a more or less similar character, so that previous remarks on pure and mixed woods will apply to each of the units or groups composing the area

Fig. 10 represents a section through an imaginary planting area, and will serve to illustrate the main points.

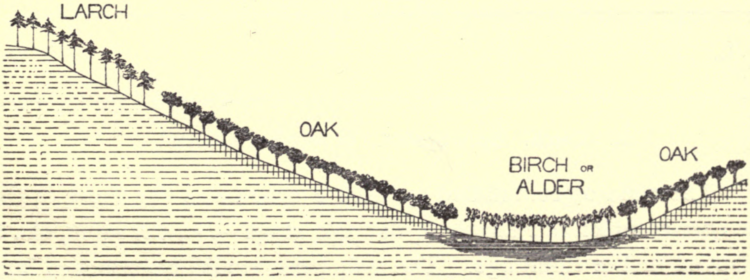

Fig. 10.
Mixture by groups.

On the hill-side, where the soil was found to be thin and possessing free drainage, larch was planted. On the lower slope of the hill the increasing fertility of the soil induced the planting of oak. This area was small, and soon gave place to a swampy bit of ground only capable of growing alder and birch. The corresponding lower sloping ground on the left was then planted with more oak.

(2) *Mixture by single trees.*

This method is excellent in those cases where a moderate planting area has soil of a constant nature throughout.

The following diagram will illustrate the advantages of this method of mixing. The plan shown is one that specially lends itself to the cultivation of timber in connection with game preserving.

O.	L.	A.	L.	O.	L.	A.	L.	O.
L.	Sp.	L.	Sp.	L.	Sp.	L.	Sp.	L.
A.	L.	Sp.	L.	A.	L.	Sp.	L.	A.
L.	Sp.	L.	Sp.	L.	Sp.	L.	Sp.	L.
O.	L.	A.	L.	O.	L.	A.	L.	O.
L.								

L. = Larch. Sp. = Spruce. O. = Oak. A. = Ash.

The main object fulfilled by such a scheme as the above is that the species which is valuable in the pole stage—*i.e.*, the larch, can be removed in the thinnings. The ash trees would be removed later on, leaving the oak trees as the main crop. The spruce would fulfil the double object of giving cover to game and shading the soil.

Such a mixture as this, however, has many serious defects which it is well to consider. It has been cited in order to show some of the principles which govern a mixture by single trees, and the objections will illustrate a few points.

The inclusion of the spruce is objectionable: firstly, because the root-system of this species is dense and shallow, and it is stated by some writers that the deep-rooted oak is deprived of a sufficient amount of moisture, tending to produce the condition known as "stagheadedness," that is, the dying of the upper branches; secondly, because the spruce is also an alternate host of a plant-louse infecting the larch; lastly, in the association of larch and spruce, the larch seems especially liable to the attacks of the larch canker.[1]

Also, it may be stated with truth that the larch would be out of place on the class of soil where oak was intended for the principal crop of timber. Unless the soil was a stiff clay, however, the substitution of the Japanese larch (*L. leptolepis*) would do away with the objections urged, to a very large extent; for a less free natural percolation of water in the soil seems to be required by this species, and also it is more immune from the larch canker.

The ideal mixture of another species with oak, where heavy oak timber is required, is beech. It is unfortunate that there is little demand for beech timber in this country.

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[1] This may be due to the fact that a soil suitable for spruce is not so for larch; moreover, the plant-louse (*Chermes laricis*) causing wounds and generally lowering the vigour of the tree, the larch becomes more liable to this disease.

CHAPTER VI

TIMBER

THE kind of timber which is required, and the class which the land will produce, are the two chief points to be borne in mind when deciding upon the planting of a wood.

Before considering the characters of the timber, however, the chief terms used in describing these must be explained.

Annual rings. In most species of trees, a cross section of the trunk reveals the fact that it is composed of a number of concentric rings, formed alternately of dark and light coloured wood. Each pair of rings constitutes one year's growth, and is termed an "annual ring." *Spring wood* is the light-coloured portion. It is less dense, and it contains larger vessels necessary for the sap to rise in spring when the buds are opening. *Summer wood* is the dark-coloured portion : it is more dense and of higher specific gravity.

Uniform rings are important in determining the quality of the timber. The breadth is usually governed by the extent to which the crown of the tree is allowed to grow, and it is even possible to trace the periods at which a high wood has been thinned, by the increased breadth of the annual rings. Each thinning allows an increased amount of light and air, and consequently an increase in the size of the crown. The result is an increase in the breadth of the annual ring during the following year. This is continued each year, until the struggle for existence is increased by the restriction due to the growth of the canopy. Consequently, *frequent and sparse thinnings* (see Chapter VII) are necessary to ensure uniform rings and, therefore, the best quality of timber.

Heart-wood (*duramen*) is the term applied to the inner, and therefore the older, annual rings. This portion no longer contributes to the vital functions of the tree, beyond the fact that it acts as a support to the crown. In the heart-wood, the colour is usually darker, and less water is contained in it; the waste products produced in the life of the tree are stored up in it, so that the woody tissue of the cells is thickened, and the timber becomes denser in consequence.

Gum resin and other substances are deposited in this portion of the trunk, and it contains little or no starch or other substances which would nourish rot-causing organisms. The result is that the heart is always far more durable than the outer, lighter-coloured, and younger rings. Heart-wood, on account of the waste products stored therein, cannot be successfully injected with a preservative.

Sap-wood (*alburnum*) comprises the outer, lighter-coloured rings; and by its means the material obtained by the roots is conveyed to the crown. This portion of the trunk is of small durability, owing to its small density and to the presence of sap.

The proportions of heart-wood and sap-wood vary in different species. In the Turkey oak, the sap-wood occupies many rings which are of small durability; in the acacia, the sap-wood is limited to comparatively few rings. In the case of the silver fir, beech, spruce, aspen, lime, hornbeam, birch, and ash, little or no deepening in colour of the older rings is observable.

When a species of tree shows a distinct heart-wood, the timber is more durable when the tree is mature than when it is young. This is especially the case as regards conifers, as, for example, the resinous heart-wood of old Scotch pine.

Medullary rays is the term applied to the lines which are seen on a cross section of such a tree as the oak. They are bands of tissue running radially from the pith, or from some of the younger rings, towards the bark; they extend vertically to varying depths. They are of importance in determining the beauty of furniture woods, and therefore of deciding their market value.

Durability.

The decrease in the supply of the more durable kinds of hard wood timber in this country, has compelled the substitution of inferior species for purposes for which they were formerly considered unsuitable. The use of the less durable timber is justified, to a large extent, by the greater perfection which has been obtained in the preservative treatment of timber; this has increased enormously the durability of the timber produced by many species, and also of the sap-wood of the more durable kinds. Information on the preservation of timber is given in Chapter VIII.

The main factors affecting durability are:—

(1) *Climate.* A climate where a short spring prevails is usually productive of a small zone of the light-coloured spring wood; consequently, the annual ring contains a larger proportion of summer wood, which is more durable. But it is necessary for the production of good timber that the species must be suited to the soil and to the climate, for the thickness of the cell walls composing the timber is dependent to a large extent on the energy of growth.

(2) *Situation.* Isolated specimens, such as are found in hedgerows (other conditions being equal), produce more durable timber than trees grown in a dense wood; in the latter case, however, if thinning is rationally conducted, this difference is more than counterbalanced by the cleanness of the timber produced from trees grown in woods. (See p. 34, *Thinning.*)

(3) *Age of trees.* Species noted for their durability when mature, are often of little value when young. This is due to the fact that in species such as oak, Scotch pine, etc., there is only a slight development of heart-wood when young, and it is this portion of the trunk, especially, which is durable.

(4) *Season of felling.* The season of felling has a considerable effect on the resistance of a timber to decay. Winter, in all cases, is the most suitable time, for the wood seasons more thoroughly if felled at that time, as it contains less sap and moisture than in summer. An example is often seen in the case of oak felled in spring for the sake of the bark, as contrasted with the same species felled in winter.

(5) *Species.* It is common knowledge that different species of timber differ in their durability. The following tables, taken from Schlich (p. 94), indicate the relative durability of the common species

of timbers; this is a general classification only, as pointed out above, and is affected by other factors.[1]

Very durable wood.

Pedunculate Oak
Larch
Sessile Oak
Scotch Pine
Black or Corsican Pine
Mountain Pine
False Acacia
Sweet Chestnut
Common Elm

Durable wood.

Ash
Larch
Scotch Pine
Silver Fir
Spruce

Wood of little durability.

Quickly-grown, slightly-resinous, coniferous timber.

Beech
Hornbeam
Sycamore
Alder
Wild Cherry
Birch
Lime
Weymouth Pine
Poplars
Hazel and Willows

TIMBER.

DOUGLAS FIR. The home-grown timber of this species is apt to be somewhat coarse and knotty, owing to the retention of its side branches even under a somewhat dense canopy.

The annual increment of the timber is large, and, under proper conditions, its value ought to exceed that of the Scotch pine.

The timber may be used for all purposes to which that of Scotch pine is applied, and as a somewhat inferior substitute for larch.

SILVER FIR. The timber of this species is coarse and usually full of knots. It is imported into this country under the name of Swiss pine.

[1] The reason for the presence of the same species in more than one class is accounted for by the more or less favourable conditions under which they grow, as, for instance, in the case of Scotch pine, which may be present in all three classes.

It may be used for all purposes for which spruce is applied, and under favourable conditions the annual increment is larger.

LARCH. This timber is in universal demand for all fencing purposes. Speaking generally, the wood of this species is used for purposes which do not entail much "conversion." It is especially valuable for telegraph poles, scaffolding, and fencing.

It is very durable, and it is stated that much of Venice is built on larch piles, as it is so well able to resist the trying exposure of alternating wet and dry conditions.

Very little larch is imported into this country, and even that small amount is usually inferior to home-grown timber.

SCOTCH PINE. The timber of this species is very largely imported into this country under the names of Dantzig, Riga, or Memel pine.

A very great variation occurs in the durability of this timber; the heart-wood of old trees is impregnated with resin, etc., and this renders the timber of great durability, but it hinders it from being successfully treated with creosote.

On the other hand, the thinnings, even when of small size, form excellent material for the temporary fencing which is always in demand on any estate.

The *principal uses* are:—Constructional timbers of all kinds, railway sleepers, etc.

SPRUCE. The timber of this species is known as "white deal" and is largely imported from Norway.

In spite of the knots which occur (especially in home-grown timber) the wood is easy to work, tough, and fairly elastic. It is not easy to impregnate with creosote, and, on this account, it is not regarded with favour by the British Government for use as telegraph poles.

It is employed for general constructional purposes, when not exposed to weather.

ALDER. Like the birch, this timber is characterised by pith flecks, which are more numerous and distinct in the commoner species.

The colour is white when freshly cut; but on exposure to the atmosphere, it assumes a deeper colour of a reddish hue. It is soft, light, easily worked, and very durable when completely submerged, but when subjected to conditions under which it is alternately wet and dry, it quickly decays.

Its *principal uses* are:—Clogs (birch is more durable); cigar-boxes; bobbins, etc.; charcoal for gunpowder. The main supply is from Northern Germany.

ASH. The timber is light in colour, with a large breadth of sap-wood. As a rule, there is only a slight difference in colour between the sap-wood and the heart-wood. The annual rings are distinct.

The timber is used for all purposes which require elasticity and strength. It is imperative, however, that the logs should undergo rough conversion as soon as possible after felling; otherwise (according to Laslett) *shakes*[1] and cracks appear which involve much loss. Trees of medium age are preferred to older specimens, as the wood of the latter is inclined to be brittle.

Coppice shoots are used for hop poles, hurdles, implement handles, whip handles, etc. The larger timber is useful for coach-building, furniture, oars, etc., and in aeroplane construction.

BEECH. The timber is of much the same colour throughout; where the older rings are darker in colour, it is usually a sign of incipient decay. The medullary rays appear to be broad, but in reality they are compound, being composed of several finer rays placed close together; a distinguishing feature is the satin-like appearance of these rays. The colour is variable, a reddish tinge being present on beech grown on good soil. This wood is largely employed for chair-making in Buckinghamshire, in which county large beech woods exist. On the Continent, it is largely employed as fuel.

Its *principal uses* are:—Furniture, tool handles, wooden screws, turnery, shoe lasts, agricultural implements, and charcoal.

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[1] *Shake* is the term applied to cracks in the trunk, which entail waste in conversion. They may run from the pith outward when the term "star" shake is used, or as in the case of a "ring" shake a separation of the annual rings takes place.

When creosoted, it makes fair fencing material, although it has the reputation of being brittle when the posts are driven in; if, however, their upper ends are cut square, and if driven in properly, there is little fault to be found in this respect.

BIRCH. The timber is soft and easily worked. It is much used for crates and all kinds of rough carving and turning, such as bobbins, toys, and sabots; also for charcoal and fuel, for which latter purpose it is in request because of its cheapness and good heating properties. Pith flecks are present in the wood.

Cases of malformation of the grain occur and these are frequently valuable for furniture, etc. The wood is of very small durability when exposed to the weather.

SWEET CHESTNUT. The wood is extremely durable and moderately heavy. Its economic value is, however, marred by the liability of mature trees to develop a shake.

It is excellent for fencing purposes, outlasting even good oak, particularly when in the ground. On the Continent, it is largely used for barrel staves.

It coppices freely and makes good hop poles.

ELM (ENGLISH). The timber is dark in colour and coarse; it is hard and durable, especially so when used underground or completely submerged.

A notable feature is the extreme difficulty with which this wood splits; and this quality causes it to be selected for purposes such as pulley blocks, naves of wheels, turning, etc. It is also used in carriage-building, for coffins, etc., and it may be looked upon as an inferior and cheap substitute for oak.

The timber varies considerably in its quality. The soil on which it is grown must be good and the climate fairly genial. Generally, it may be taken that the timber depreciates in quality the further north it is grown, so that in Scotland the timber of the wych elm is preferred.

HORNBEAM. This wood is hard, tough, and heavy; very close in the grain and difficult to split.

The home-grown supply is comparatively small. A certain amount is imported from France; but probably the best timber is grown in Russia, where the largest diameter of stem is produced.

It is used for shoemakers' lasts and pegs; cogs and bearings in certain machinery, mallet heads, tool handles, etc.

LIME. The timber is soft and easily split; the pith rays are fine. This wood is easily distinguished from that of the sycamore by the absence of the lustre seen in the rays of the latter species.

It is used for turning, carving, founders' patterns, and as blind wood in furniture and under veneer.

OAK. The best timber is durable, hard, heavy, capable of receiving a high polish, and is always in great demand. The wood of the *sessile* species usually has narrower annual rings, and, being softer and more easily worked, is preferred for those purposes where durability is not the primary object. Speaking generally, coarser but more durable timber, with broad annual rings, is obtained from trees growing in an isolated position; and finer-grained, but frequently more ornamental, timber is produced by trees growing in a dense wood. The timber is employed for a variety of purposes. For all constructional works where strength is important, the oak stands pre-eminent.

Its *principal uses* are:—Panelling, furniture, flooring, gate-posts, joiners' and carpenters' work, staves for casks, etc.

SYCAMORE. The value of the timber depends largely on its size and colour. It is compact, durable under dry conditions, and capable of receiving a high polish. It splits evenly, and there is little difference in colour between the younger and the older rings.

In some cases, numbers of trees from the same wood are found to be discoloured when cut, which largely lessens their value. This may be due to local variations in the soil.

Its *principal uses* are for cabinetwork and furniture (especially panelling), wooden dishes, shop-boards, wooden type, and turnery generally. When of sufficient size and straightness it is employed for calico-printing rollers, and it realises a good price for this purpose.

An abnormal disposition of the grain is sometimes found and is highly valued, especially for the backs of fiddles.

CHAPTER VII

CHARACTERISTICS OF COMMON FOREST TREES

THE following notes indicate the chief individual requirements of each of the more common forest trees of these islands.

Conifers.

1. Scotch Pine
2. Austrian Pine
3. Douglas Fir
4. Spruce
5. Menzies Spruce
6. Larch
7. Japanese Larch
8. Silver Fir

1. Scotch Pine (*Pinus sylvestris*).

Distribution. It is indigenous to this country, at one time forming vast pine woods in Scotland, but it is most prevalent on the shores of the Baltic.

Soil. This species accommodates itself in a remarkable manner to a variety of soils and climates, growing both on dry sandy soils and marshy ground. A fairly deep soil is appreciated.

Nursery treatment. The seed ripens in the October of the year following that in which the cone is first formed, and the cones are best gathered in the following December. A good sample should show a germinating capacity of about 70 per cent.

The seedlings should be planted out in lines at the age of two years, and they should stay in these lines for another two years.

Two-year-old seedlings are sometimes used for planting, but this is hardly advisable for fear of the small plants being suppressed by weeds and grass.

In this country, woods are usually established by planting young trees raised in a nursery. Sowing directly on the site on which it is proposed to establish the wood, is seldom successful, owing to the rapid growth of surface herbage, and to the ground seldom being in a proper condition (see *Natural Regeneration*, p. 27).

Thinning. This should be done sparsely and repeated often, up to the age of fifty or sixty years. The removal of live branches is a mistake, although the knocking off of dead branches will improve the quality of the timber.

A. C. Forbes, in "English Estate Forestry," advocates the following method of growing Scotch pine.

"The sole and only secret of growing it to perfection consists in sowing or planting it thickly at the outset and then leaving it entirely alone. No thinning should be done whatever, beyond the taking out of the dead or dying trees at periodic intervals."

The objection to this plan appears to be the presence of dead stems in the wood, as the species in question is particularly liable to attacks from insects and fungi. Moreover, where there is convenience for creosoting, the thinnings are a profitable item, even the earlier ones.

2. Austrian or Black Pine (*Pinus laricio, var. austriaca*).

Distribution. This species is not indigenous to this country, its natural home being in Lower Austria, Dalmatia, and the Eastern Alps.

Soil. Calcareous soils are specially preferred, and probably the finest specimens are found on the chalk, provided there is sufficient depth of soil. It is probably more easily content in this respect than any other species of conifer.

Nursery treatment. See Scotch pine, which it resembles; but as it is capable of a more dense canopy, it is better able to keep up the soil fertility.

3. Douglas Fir (*Pseudosuga Douglasii*).

Distribution. This species is not indigenous to this country, its natural home being in temperate North America.

Sometimes no differentiation is made between the free-growing species, growing on the lower slopes, and the variety *glauca* growing at greater elevations. The former should always be specified when an order is given for seeds or plants.

This species was introduced into this country about one hundred years ago. It is eminently suited for pure woods; the height-growth is possibly as rapid as any conifer grown in this country, under suitable conditions. The shade-bearing capacity of this tree is probably under-estimated ; and the timber, to be clean, must be grown under a dense canopy. If planted with other species, the timber is apt to be rough and to possess large knots, as most of our shade-bearing trees are not suitable for the soil required by the Douglas fir, and are overgrown on the soils suited for this species. This has led to an under-estimation of the quality of the timber. Moreover, during the time that the timber now on the market was planted, the seed of the Douglas fir was expensive ; hence the rarity of pure woods of it.

The timber properly grown is probably of 20 per cent. more value than Scotch pine, on an average. This species has the power of producing a new leader when this is lost—unusual in conifers.

The soil suitable for this species must be capable of free natural drainage, and in this class of land—provided that the subsoil is not chalk—good timber, abundantly produced, is procured.

Nursery treatment. This resembles that of the spruce. Frost protection may be required in the nursery.

4. Common or Norway Spruce (*Picea excelsa*).

Distribution. This species is not indigenous. The centre of its distribution is Central Europe. According to Brown, it was introduced into this country in 1548.

It is a tree naturally growing on the lower mountains, but it descends to the lowlands on the shores of the Baltic. According to Schlich, it is found in the Alps at an elevation of 6,000 feet.

Soil. The root-system of this species is shallow ; consequently, it is liable to be blown down by wind, sometimes to a considerable extent. It is much damaged by drought.

The best specimens are found in places where the subsoil is moist and cool. Only small demands are made on the soil fertility, and its effect on the soil is good, since a close canopy is maintained throughout life. Its greatest perfection is reached perhaps on loams and shales.

Nursery treatment. This much resembles Scotch pine. The seedlings are lined out at the age of two years as a rule, although this sometimes takes place at one year.

Thinning. Over-thinning, especially in the earlier stages, is the principal cause of the inferior quality of our native timber. This species parts with its side branches with great difficulty. Therefore, little or no thinning should be done during the earlier stages.

5. Menzies or Sitka Spruce (*Picea sitchensis*).

Distribution. This species was introduced from America by Douglas in 1831.

Soil. The soil requirements are similar to those of the common spruce. It seems capable, however, of flourishing in a soil of a far more acid nature than the latter species.

6. Larch (*Larix Europœa*).

Distribution. This species is not indigenous, having been introduced into this country, according to Brown, in 1629. It was not, however, planted to any extent until the year 1725, when the Duke of Atholl planted it extensively.

The natural home of the European larch is in the Alps and the Carpathian Mountains. Another species, the Japanese larch, is deserving of attention and will be dealt with later.

Soil. The larch is essentially a tree of a mountainous district, and in its native home the "larch disease" is of small account. The chief requirements as to soil seem to be that a free natural drainage is imperative.

No tree is more remunerative when healthy; but, on the other hand, the crop may be a failure.

Sandy soils, although possessing natural drainage, usually produce many specimens hollow at the base. Trees in this condition are known to the practical man as being "pumped." The ideal site for the larch is a fairly steep slope, with a subsoil of rotten rock, and possessing plenty of moisture; but it must be absolutely free from stagnation. An eastern aspect should be avoided at all times (see *Nursery*, p. 7).

This valuable species is, unfortunately, especially subjected to severe attacks of both insects and fungi, and these can only be kept in check by maintaining a free and vigorous growth; at times it may be necessary to sacrifice the cleanness of the timber by vigorous thinning, as the effect of this is to give an increased vitality to the remaining trees. It is only during the first fifteen years of its life that infection from the larch disease is likely.

Nursery treatment. It is important that the seed be selected from sound, well-grown trees.

Diseased trees are especially prolific in bearing cones, and when these are gathered for a fixed price per bushel, it is probably too often the case that many are gathered from infected trees. It is unlikely that this disease is ever transmitted through the seed; yet, at the same time, seed from a diseased tree is unlikely to produce so vigorous a plant as that obtained from sound specimens. Imported seed is preferred by many and it has much in its favour, for the probability is that it has been collected from healthy trees.

The seed is usually sown broadcast and should be covered very thinly. The seedlings may be lined out the following year, and should be left in the lines for two years. There is some difference in the size of the transplants, and it is the opinion of many practical foresters that the weaker plants are obtained from the seed which grew at the apex of the cone.

The effect of a pure larch wood is not conducive to the upkeep of the fertility of the soil. It is essential that the larch, as a light-demanding tree, has a good supply of light and air; hence a growth of surface herbage is always present when the larch is not mixed with other species. Pure woods are permissible, however, when the soil conditions are favourable; though the timber may not attain the same size in the pure wood as when mixed with a shade-bearing tree such as the beech.

Thinning. The larch develops lateral branches of small size which are quickly killed by shade ; hence thinning should be begun early and continued at regular intervals. A free circulation of air around the stems is imperative, and the crowns also must have air. On the first signs of disease, it is advisable to make an additional thinning.

7. **Japanese Larch** (*Larix leptolepis*).

Distribution. This species is not indigenous to this country, being an inhabitant of Japan, as its name implies. It was first introduced in 1861.

Soil. In many places, where the European larch will not thrive, this species will grow well. The author recently experimented with it on black fen-land; the three years' growth which has taken place since planting, leaves nothing to be desired in any respect.

Details of cultivation are similar to those of the common larch.

8. **Silver Fir** (*Abies pectinata*).

Distribution. This species is not indigenous, but it has been growing in this country for the last three hundred years, its natural home being Central Europe and Northern Asia.

Soil. This should be of medium quality and of fair depth ; but this species is not very particular as to its soil requirements. When the soil is deep, it is very storm-firm, in the opinion of the writer, although the fact is disputed.

Nursery treatment. The seedlings are of slow growth and, when young, are liable to damage by frost. They require shade in their early stages.

Small patches of seed may be sown directly in the woods.

Thinning must be done sparsely. This species is of slow growth at first and little or no thinning will be required. The lateral branches require a thick canopy for their removal.

Broad-Leaved Trees.

1. Alder
2. Ash
3. Beech
4. Birch
5. English Elm
6. Wych Elm
7. Lime
8. Oak
9. London Plane
10. Poplar
11. Sycamore
12. Willow

1. Alder (*Alnus glutinosa*).

General. This species deserves more attention than is given to it, as a rule. It is most valuable for planting on wet soils if they are porous. It is frost-hardy, and under proper management is capable of making a fair return from what is otherwise useless ground.

Distribution. It is indigenous in Great Britain and Ireland, Europe and North Africa.

Soil. Moisture is essential, and the alder is exacting in this respect. Stagnant water is injurious. Peaty soils may be usefully planted with this species.

Nursery treatment. If there is no damp spot available in the nursery, watering must be freely resorted to.

The seed ripens in October and should be sown in spring. The depth of the covering should not be more than ¼ of an inch. Owing to the nature of the soil, the seedlings are specially liable to frost-lifting (see p. 12). The seedlings are lined out at one year old and left two years in the lines.

Subsequent management. The alder is usually pit planted, and may be grown either as high-forest or coppice.

The rotation for coppice is 25—35 years. The upkeep of soil fertility need hardly be considered, owing to the nature of the soil on which this species is commonly planted. Worn-out stools should be renewed by layering a coppice shoot.

2. **Ash** (*Fraxinus excelsior*).

General. This species is probably as profitable as any, provided that the soil is suitable. The demand for good quality timber can hardly be met by our native home supply; moreover, the rotation is a short one compared with many species. Consequently, wherever the soil is suited to this species, it should form the bulk of the crop. The importation, however, of the American ash tends to lessen the demand for our home-grown wood, although the foreign wood is inferior.

Distribution. This species is indigenous to this country and in Europe. It is represented by *F. americana* in America.

Soil. Moisture is essential, but this must not be stagnant; a deep, rather strong loam produces the best timber, and the presence of lime is advisable. Light or acid soils are useless, so that, when these occur, some other species must be chosen.

Nursery treatment. The seed germinates during the second spring after the ripening. It is best preserved bedded in a ditch mixed with sand, and kept stirred from time to time to prevent heating. The seed is sown broadcast, and should be covered to a depth of from ½ to ¾ of an inch. The seedlings should be lined out at one year old, when they may be left for one or two years, according to the class of plant required.

Subsequent management. Ash is usually planted in pits. *High forest* or *coppice* may be used, but the former is the more profitable. No thinning should take place for the first twenty years, but after that period regular and careful thinnings must be conducted. The ash is especially liable to be "drawn up" if too many trees are left to the acre, and when this condition has become at all pronounced, it is difficult or impossible to obtain good timber.

Recently planted trees are liable to damage by frost, which is apt to destroy the leading shoot. This species may be pruned when young in order to control the shape of the stem.

The effect on the soil fertility is moderate; but as the class of soil employed for ash is good and the rotation short, the upkeep in soil fertility is less important than in the case of the oak.

3. **Beech** (*Fagus sylvatica*).

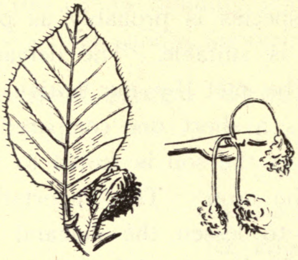

Fig. 11.

BEECH
(*Fagus sylvatica*).

General. This species is chiefly valuable on account of its effect on the soil fertility. It is intensely shade-bearing, and this property, combined with a heavy leaf-fall, tends to accumulate a thick layer of humus, which makes the beech unsuitable for game covers, as no cover will grow beneath its shade. It is most excellent for mixing with the more valuable light-demanding species of trees; on the Continent, it is used more generally for this purpose, as the timber may be disposed of at a fair price.

Distribution. This species is indigenous to this country and is planted in Scotland. It is found throughout Europe and Western Asia.

Soil. The beech is the prevalent tree on chalk downs and thin limestone soils. It is deep-rooted and storm-firm, and can stand a considerable degree of cold in winter, but the young seedlings are liable to injury by late spring frosts. For the production of first-class timber, a middling depth of soil is required, and marls and chalk show the finest specimens.

Nursery treatment. The beech "mast," as the nuts are called, ripens in the autumn and should be stored under cover until the spring. Germination takes place about four weeks after planting if the weather is favourable. A good sample should show a germinating percentage of 50.

The seed should be covered to a depth of rather more than half an inch. The plants should stand two years in the seed bed and two years in the nursery lines.

Subsequent management. The beech is usually planted in pits. The management depends on the requirements of the species mixed with it. Beech seldom forms pure woods of any size,[1] and its chief use is as a protective agency for more valuable species.

4. **Birch** (*Betula alba*).

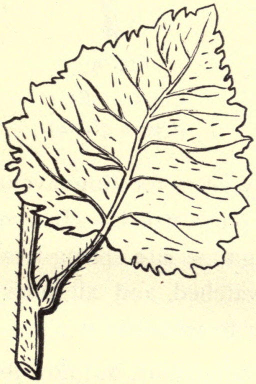

Fig. 12.

COMMON BIRCH
(*Betula alba var. pubescens*).

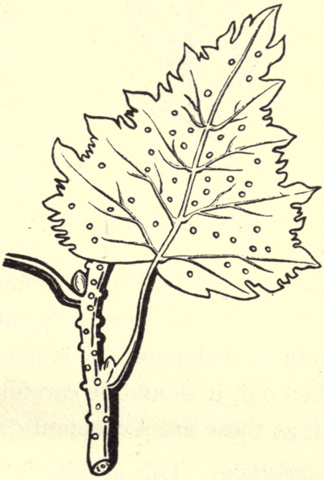

Fig. 13.

SILVER BIRCH
(*Betula alba var. verrucosa*)

Distribution. The birch is indigenous to this country. It forms large pure woods in Siberia.

Soil. Few species are less exacting as regards the quality of soil. Natural regeneration, where the natural herbage is short, occurs freely.

Nursery treatment. The seed ripens in autumn. It must be carefully stored through the winter, or the germinating capacity will be impaired. In the south of England, on dry soils, the seed ripens earlier, so that, if the autumn is open, it may be sown at once, when stronger plants will be obtained. A very slight covering of soil, or none at all, should be given.

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[1] Except, perhaps, in Buckinghamshire.

5. English Elm (*Ulmus campestris*).

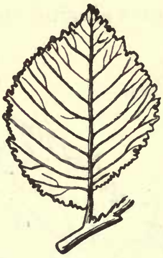

Fig. 14.

English Elm
(*Ulmus campestris*).

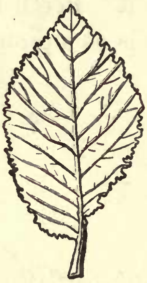

Fig. 15.

Cornish Elm
(*Ulmus glabra*).

General. This species is commonly seen forming avenues and park "clumps," but rarely forming pure woods. It requires a moderately mild climate, but is hardy against late spring frosts.

When old, it should be carefully watched, and all heavy limbs removed, as these are a constant danger to passers-by.

Distribution. This species is not indigenous, but now forms our commonest park or hedge-row timber throughout the greater part of England. At the Border, the two species occur in about equal numbers, while further north *U. montana* is the commoner species.

Soil. The soil must be deep and fertile, and the best developed specimens occur on alluvial soil. Such soil is, of course, in the generality of cases, far more valuable for agricultural purposes; hence the uses of this species are chiefly ornamental.

Nursery treatment. The seed rarely ripens in this country, although, in the south of Europe, a fair germinating percentage is obtained by sowing the seed as soon as it is ripe, *i.e.*, in June; even thus, 35 to 45 per cent. germination is considered good.

The usual methods of propagation are by root suckers and layers.

Subsequent management. The elm is of rapid growth, a plant having obtained a height of ten feet in six years.

6. Elm: Wych, Scotch or Mountain (*Ulmus montana*).

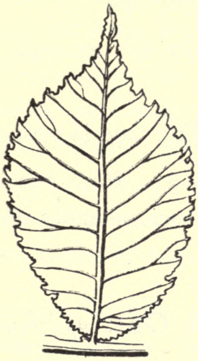

Fig. 16.

WYCH ELM
(*Ulmus montana*).

This elm resembles the preceding species. It is, however, of a more sturdy and robust nature, with larger leaves, and a more compact habit.

Naturally it has a more northerly range than the English elm, and is capable of growing at greater heights and on poorer soil, in which localities it produces better timber than the latter.

When grown under congenial conditions, however, the timber of the English species is preferred.

Plantations are formed by seedlings and layers.

The seed should be sown in June as soon as ripe, and the seedlings left until the following spring, when, as growth is vigorous, they should be ready to place in the nursery lines, which should be 1 ft. 6 in. apart. For other details, see the preceding species.

7. Lime (*Tilia Europœa*).

General. This species is of very small account in sylviculture, but it is valued from an arboricultural point of view, its symmetry of form giving it a position amongst avenue trees. The bark produces materials for mats, packing, etc. This species is fairly storm-firm, but is susceptible to frost.

Distribution. The lime is not indigenous, the centre of its distribution being Central Europe, and here it is usually represented by *T. parvifolia* and *T. magnifolia.*

Soil. To produce really fine examples, the soil must be fairly deep, fresh, and porous.

Nursery treatment. The lime is propagated by layering.

Subsequent management. This species is practically never grown for economic purposes, usually forming avenues or ornamental timber.

8. **Common Oak** (*Quercus pedunculata*).

Sessile Oak (*Quercus sessiliflora*).

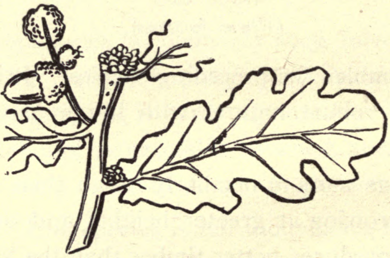

Fig. 17.
COMMON OAK
(*Quercus pedunculata*).

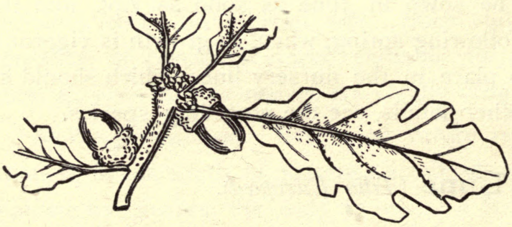

Fig. 18.
SESSILE OAK
(*Quercus sessiliflora*).

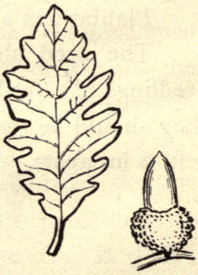

Fig. 19.
TURKEY OAK
(*Quercus cerris*).

General. These two species are often regarded as merely varieties of the one species, *Q. robur.* The nursery treatment is similar for both species, and timber merchants do not differentiate between the timbers. The sessile species is, however, less particular as to soil requirements than the common oak, and it gives better results on poorer soils and in exposed situations.

The specific names indicate the most striking features of identification. The common oak bears its *fruit* on a peduncle or stalk, while on the sessile species the *fruit* has no stalk. *The converse is the case as regards the leaves.* The sessile oak is of more erect growth, and has less tendency to produce large limbs and spreading crown than the common species.

Distribution. Indigenous in this country, the common oak, however, has a less northerly range; moreover, the sessile species is capable of growing at a greater elevation. The latter appears to be more susceptible to extreme winter cold, the common oak being more dependent on the summer temperature.

Soil. The best soil is a deep, rather stiff loam, and on this class of soil the most favourable growth is obtained. The height-growth is largely dependent on the depth of the soil and on the amount of moisture; the latter should be present in fair abundance, but never stagnant. Clay, if not too stiff, produces good oak timber even when the trees are grown in pure woods. On light soil, oak must be under-planted with some shade-bearing species, preferably with beech. When large timber forms the object of management, the common oak requires a better soil, and is more dependent on moisture.

Nursery treatment. The seed should be dibbled in at a depth of about 1½ inches. This gives a rather better result than the usual method of sowing in drills.

The one-year seedlings are transplanted into lines and may be planted out at the age of three years; but, as soils suitable for oak usually possess a rank natural herbage, it is advisable to employ five-year-old plants twice transplanted.

A. C. Forbes advocates that oak seedlings be left for two years after being sown in drills. If there is a probability that a tap-root is being formed, it may be severed by means of a sharp spade inserted in the ground without disturbing the seedlings.

The young plants stand pruning well, both root and shoot.

Subsequent management. Frequent and sparse thinnings are necessary, in order to give as slight a change as possible as regards light and air round the stems; otherwise both species are liable to develop the dormant buds on the stems, lessening the quality of the timber and restricting the height-growth. These shoots are known as "breast-wood" and "water-shoots." Oaks are of very slow growth, and care must be taken that, when planted with other trees, they are not suppressed by the more rapidly growing species. This may be effected by "lopping" the fast growers, or giving the oaks a start by planting them pure and introducing the shade-bearers when the crowns of the oaks begin to open out. These species are so slow in coming to maturity and so uncertain in their development, that it is doubtful whether they will play an important part in the future forestry of Great Britain; more especially as land which will grow really good oak, is also capable of producing other crops from which a more immediate return may be expected.

9. London Plane (*Platanus acerifolia*).

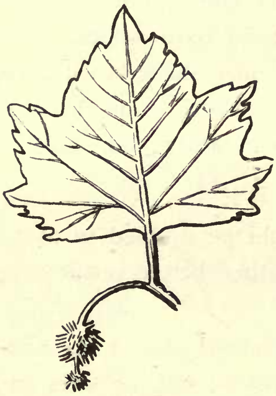

Fig. 20.
London Plane
(*Platanus acerifolia*).

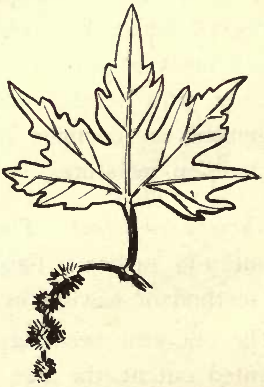

Fig. 21.
Oriental Plane
(*Platanus orientalis*).

This species, although of small sylvicultural value, is of such importance for town planting that it deserves notice. Its suitability for this purpose lies in its graceful appearance and immunity to the ill-effects of smoke.

It may be propagated by seed (in hot summers), layers and cuttings.

10. **Black Poplar** (*Populus nigra*).

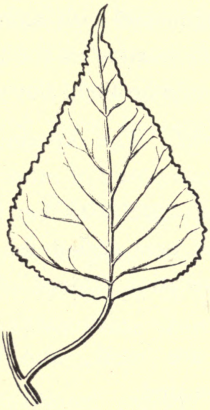

Fig. 22.
BLACK POPLAR
(*Populus nigra*).

Distribution. This species is of Canadian origin, whence it was introduced into this country, via Italy; hence its name, black "Italian" poplar.

Soil. Eminently adapted for wet spots where, with the exception of the alder, no other species will grow.

Nursery treatment. This species is propagated by means of cuttings planted in the woods. The growth is extremely rapid.

11. **Sycamore or Maple** (*Acer pseudo-platanus*).

General. In Scotland this species is commonly known as the "plane tree," and this is apt to cause confusion to the southerner, who only knows the name in connection with the genus *Platanus*.

Distribution. The chief home of the sycamore is Central Europe and Western Asia; it is probably not indigenous in this country.

Its place is taken in the more northerly countries by the Norway maple.

Soil. It is quite hardy as regards winter frosts. The soil must be of at least medium quality, fresh and porous ; it is more particular than the Norway maple in this respect.

Nursery treatment. The seed requires careful treatment during the winter, or it is apt to lose its vitality. The best way is to place it in a trench in the ground mixed with sand. The seed should be carefully watched, and sown as soon as the first signs of germination appear. The seedlings should be lined out when one year old.

Subsequent management. The sycamore is usually found in groups throughout woods composed of other species.

Pruning may be done, as the timber is valuable if the stems are large and clean. The best period for pruning is July, as the wounds caused by the operation "bleed" less when made at this period.

The coppice shoots are weak, and high forest is the only system which is to be advocated.

12. Willow[1] (*Salix*).

There are many species. In every case, the willow is propagated by means of cuttings taken from one-year-old shoots and inserted in the ground during early spring.

Some species are merely a few inches high; while, on the other hand, the "white" willow and the "crack" willow attain a considerable size. These species are usually found on river banks; and the soil should be deep and fresh. The growth is rapid, and the white willow is often "topped" or "pollarded" at a few feet from the ground, the resulting shoots being cut periodically for pea-sticks, etc.

A variety of the white willow is used in the manufacture of cricket bats, and is most profitable under suitable conditions of growth.

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[1] The species, variations and crosses of the Poplars and Willows are innumerable, and critical details of these are far beyond the scope of this work. Of other genera, many species have been omitted, as their inclusion would have rendered the work too voluminous.

CHAPTER VIII

GENERAL

THERE are many details which have to be considered by a forester, but which are beyond the scope of such a book as this. It might be well, however, to consider, very briefly, a few of those which are more important or interesting.

Pruning.

Pruning is the term applied to the artificial removal of unnecessary or undesirable branches or roots. It is an operation of far less importance in sylviculture than in horticulture, but it is occasionally necessary.

Under a properly-managed canopy, lateral branches, which are useless as timber, are killed off at a comparatively early age. In some cases, although dead, these branches retain their connection with the trunk, so that the base becomes buried in the wood of the latter as each successive annual ring is added, forming a loose or black knot. In the case of some conifers, it is advisable to knock these branches off as soon as they attain a sufficiently brittle condition. This applies especially to larch, and helps to prevent the growth of larch canker.

Actual pruning is usually only carried out in the case of isolated trees; also, specimens grown to any considerable size in the nursery will probably require pruning, both of shoots and roots. It is frequently necessary to shorten the tap-roots of oak transplants before planting. Some species of trees tolerate pruning better than others. Broad-leaved trees, taken as a whole, stand pruning better than conifers; but, even in the former case, it is not advisable to prune branches of a greater diameter than four inches. Oak, ash and sycamore stand pruning well, but if the pruning is severe, dormant buds are apt to develop; this is especially the case with oak, the resulting shoots being popularly known as "breast-wood," or "water-shoots." Soft broad-leaved trees, such as willow, etc., are apt to decay before the wound is healed.

The best time for pruning is when the sap is dormant. Spring is the worst time, as the sap pressure is greatest then, and extensive "bleeding" results. All limbs pruned should be removed with a clean cut, *close to the stem or trunk*, so as to allow the bark to heal over. The cut surface should receive a covering of Stockholm tar, or lead paint, which acts as an antiseptic. If a portion only of a branch is removed, the cut should be made immediately above a bud or small branch, in order that the sap may continue to be raised through the remaining part. If this point is not observed, the stump left will die and decay, ultimately spoiling the timber, if not killing the tree.

Wind Damage.

Some idea of the damage caused by wind may be gathered from the fact that, in the year 1893, no less than 1,850,000 trees, valued at £282,263, were blown down in Perthshire and Forfarshire.

The best class of timber, possessing long clean boles, is particularly liable to such damage, owing to the fact that the wind is able to obtain greater leverage over the crown, for which reason the danger is greater when the end of the rotation is near, and when the trees are quite mature. Hedgerow timber, which has been growing in an isolated position all its life, is more immune from damage, in spite of the proportionately greater surface of crown exposed to the wind.

The damage due to wind may consist of:—

1. The complete blowing down of trees, which interrupts the working plans where such exist, and which, in addition, causes a direct financial loss, owing to the actual damage to the timber.

2. The loosening of the root-system of plantations in the pole stage, and the lessening of the intimate contact of the roots with the soil.

3. The lowering of the soil fertility by dry winds, which cause drought, and also by blowing away the surface litter.

Winds blowing uphill are comparatively harmless, because their force is moderated by the friction of their uphill course; also the root-system and the crown are more developed on the lower side of the slope, so that far more force is required to uproot a tree when the wind is blowing uphill than when it is blowing down the slope.

Species resistant to wind. Certain species are more or less capable of resisting wind, owing to the natural formation of their root-system. But, on the other hand, there are other factors which increase or diminish the danger. The oak is the most storm-firm of our broad-leaved trees, then elm, ash and sycamore. Silver fir and Scotch pine are the best of our conifers ; but if these species are planted in an impervious subsoil, they are equally liable to damage.

Shelter belts. When an area is planted on an exposed site, shelter belts should invariably be placed on those sides from which the prevailing winds of the district may be expected.

The species forming the belt must be storm-firm and well suited to the soil. Sycamore, elm, mountain pine, Scotch pine, Austrian pine, Corsican pine, are suitable trees for this purpose on poorer soil. These should all be planted about 10 to 12 feet apart, and any large limbs should be removed. It must be remembered that height-growth and clean timber are *not* the chief requirements for a shelter-belt.

Uneven-aged and mixed woods. Uneven-aged woods are less liable to damage than even-aged mature woods ; for the younger trees tend to prevent the swaying of the more mature stems. Under-planting is often advisable, therefore. The mixing of storm-firm species with those liable to damage, renders the latter more immune.

Thinning. Light thinning,[1] often repeated, is perhaps the most important precaution to be observed. In an exposed situation, the main point is to encourage every tree to develop a well-developed root-system and a well-balanced crown.

---

[1] "Light" in this case means that only a small number of trees are removed. Not in the sense meant when the term "light-thinning" is used in Natural Regeneration. (See p. 27, and par. 2 of foot-note on p. 38.)

General. It will, of course, be understood that these remarks apply only to the fringe of a wood exposed to the prevailing winds, and to those situations especially liable to damage from this cause.

The Care of Ornamental Timber.

The decay of ornamental timber is such an insidious process that the owner is often unaware of the existence of the disease before the damage is irretrievable. To the casual observer, it happens, very frequently, that an avenue of elms has a very presentable appearance in summer, because the foliage covers the defects; but an examination often shows that there is hardly a single specimen that is sound, nearly every tree possessing more or less large cavities in which water is standing. Gradually the heart-wood of the tree disappears, until a mere shell is left of the trunk, with perhaps the alburnum, or sap-wood, of only sufficient thickness to fulfil its function. The limbs usually continue to be sound, and their weight increases, while their supporting trunk is diminished in strength. This condition of affairs continues until a storm occurs, and then the limbs fall off. The whole symmetry of the crown is destroyed, and, at the same time, the fall of the limbs is a serious danger to men and animals.

The reason why one species of tree is so long-lived and others comparatively short-lived seems to depend largely on the density of their timber and on the resistance to the attacks of bacteria and fungi; so that if these attacks can be prevented, the life of a tree ought, theoretically, to be indefinitely prolonged.

The origin of decay, in the majority of cases, is due to one of three causes:—(*a*), the lodging of water in some depression formed by the conformation of the outline of the trunk; or (*b*), to faulty lopping or pruning; or (*c*), to a limb being broken off by wind, leaving a stump projecting from the trunk.

In the first case, owing to the conformation of the main branches, water has been continually collecting in the cavity of the fork (see Fig. 23, *a*); the surrounding bark becomes more or less permanently sodden, and, being free from exposure to air currents, forms an ideal breeding-ground for rot-causing bacteria, and for the germination of the spores of various species of fungi. If this condition of affairs is allowed to continue, the tree is doomed; all the branching limbs will eventually break away, unless some measures are taken to check an increase in the size of the cavity. A cavity in this position will be full of water, and this must be removed at once. The depth of the hole is measured with a rod, and a hole is bored through the trunk with an auger, in an upwardly slanting direction, as shown in Fig. 23, *b*; the rotten wood is cut away; the freshly exposed surface of healthy wood is painted with a carbolic acid mixture, or other suitable preservative; the hole and cavity are filled with cement. If the damage is not too far gone, and

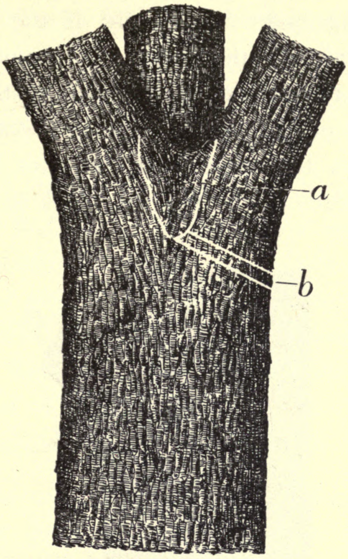

Fig. 23.—Trunk of tree showing how rot often commences by the retention of rain-water in the fork, and the method of treatment. (*a*), cavity formed by water collecting in the fork; (*b*), auger-hole made to drain off the water.

if the operation is carefully conducted, disease is checked and the life of the tree is very considerably prolonged.

In the other cases, when from one or other cause a stump of a branch has been left on the trunk, this stump will die if it does not possess a sap-lifting bud. Ordinarily, if the branch were sawn or cut off quite close to the trunk, the wound would gradually heal over and so prevent the entrance of destructive organisms; but the protrusion of the dead branch prevents the occlusion of the wound, so that the wood soon becomes infected, and rots; then the decay spreads down into the trunk as shown in Fig. 24.

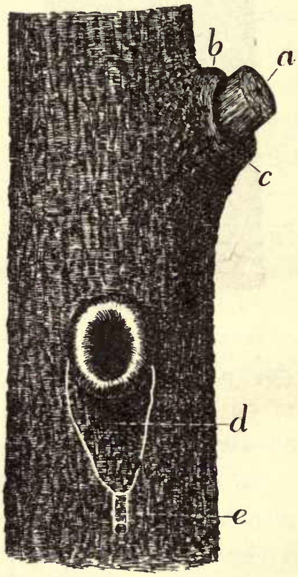

Fig. 24.—Trunk of tree showing rot, due to broken or improperly-pruned branches, and the method of treatment. (*a*), dead stump of branch which prevents the occlusion of the bark at *b.c.*, until the decayed portion has spread into the trunk forming a cavity as *d*; (*e*), auger-hole made to drain the water from the cavity.

The method of treatment is on similar lines to the above; but in this case, the dead stump must be sawn off flush with the trunk, all dead wood cut out, the exposed wood treated with preservative, and the cavity is filled up with cement, which must be finished off level with the surface of the trunk. Then there is every chance of the bark growing over the wound and completely healing it.

The objection to this process is that, when the tree is felled and sold, the blocks of cement may have been grown over, and are only discovered by the teeth of the saw. But timber of this class is usually left as long as it will stand, because its chief value at this stage is as ornamental timber.

Starvation is a danger to which trees growing on lawns are sometimes liable. A lawn may have been constantly mown for season after season, the cut grass removed, and nothing returned to the soil in its place; moreover, the leaf-fall will have been carefully swept up, which still further impoverishes the soil. It must be evident, therefore, that the soil will eventually become abnormally poor by the removal of both grass and leaves; and trees growing under such conditions are certain to deteriorate.

The application of a manure is usually followed by a marked improvement in the foliage. The turf should be removed in even-sized sods, which are rolled and stacked in a convenient place, the distance from the trunk to which the sods are removed being governed by the spread of the branches. The soil exposed should be removed to a depth of three or four inches, if this can be done without disturbing the roots, and replaced with good leaf-mould compost to which has been added a small portion of well-rotted manure—an old mushroom bed is specially suitable. This is made firm, and the turf is relaid. An improvement is certain to follow.

PRESERVATION OF TIMBER.

The antiseptic treatment of timber lessens the liability to decay, and makes the wood of many species which naturally are of small durability, available for any purposes for which previously it was unsuited.

A variety of substances is used, but creosote is perhaps the best for outdoor purposes on an estate. The advantages of creosote are that it is essentially antiseptic, it does not corrode iron, and it is easily applied; on the other hand, it is rather expensive and it is inflammable.

The heart-wood of larch, oak, etc., cannot be successfully treated, but these are sufficiently durable untreated. Thinnings of Scotch pine for temporary fencing, deal of all kinds, gates, gate-posts and all fencing, are rendered more durable by creosoting.

The durability of the timber treated will depend, however, on the quality of the material used and the method of application.

There are three methods in use :—

(1) Impregnation under pressure.
(2) Simple immersion in cold creosote.
(3) Simple immersion in hot creosote.

The first method requires such special apparatus as to make it available only for treatment of large quantities of wood. It is quicker, and more thorough, however, than the others.

The second method is of no great value, where permanency is required, though timber so treated is more durable than when untreated.

The third method is the best for general estate purposes, although it is slower than the first. A suitable plant is illustrated in the diagram. The timber to be treated is placed in the steeping tank; sufficient creosote is pumped up from the storage tank; and the fire underneath is lighted.

The temperature is an important consideration, as if heated above 200° F. there is a great waste of creosote. It is advisable, also, to have a lid to the steeping tank, even if only loosely fitted, to prevent loss of creosote.

Messrs. Black advise that the creosote should be kept hot during the day and allowed to cool during the night. Two or three days is required according to the size of the logs which are being treated. It is important that the timber should be well seasoned, so that the creosote may enter the wood readily.

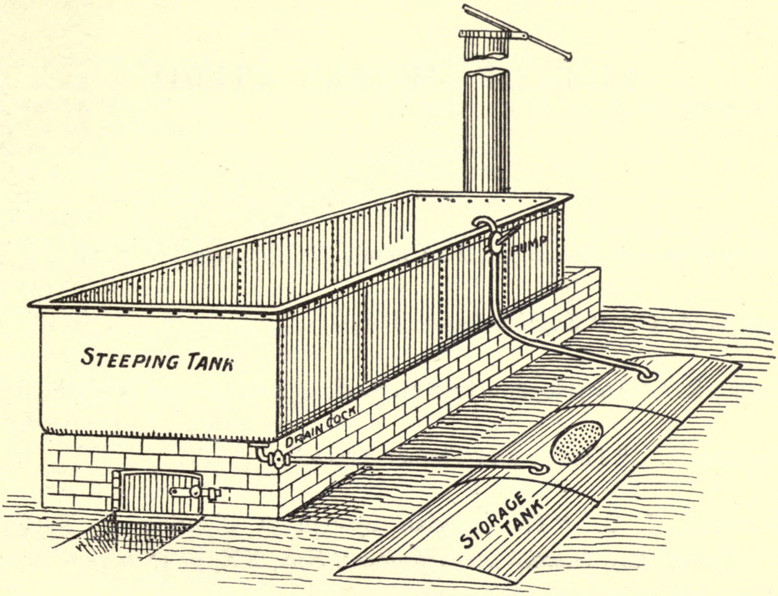

Fig. 25.—Creosote Steeping Plant (Black's) for the preservative treatment of timber.

Where much timber is being used, such an apparatus should be valuable; and where a sawmill exists, it would form a source of income, as there is always a great demand for treated timber.

LIST OF WORKS CITED

EBERMAYER. "Physiologische Chemie der Pflanzen," I, p. 761.

FORBES, A. C. "English Estate Forestry."

HESSE, R. "Encyclopädie und Methodologie der Forstwissenschaft."

LASLETT, T. "Timber and Timber Trees."

MAXWELL, J. S. "The Belgian System of Planting on Turfs." *Trans. Roy. Scottish Arboricultural Soc.*, XX, p. 1.

MITCHELL, A. "A Handbook of Land Drainage." Published by *The Land Agent's Records, Ltd.*, 1898.

SCHLICH, W. "A Manual of Forestry."

SUTHERLAND, J. D. "A General Description of the Woods on the Appin Estate in Argyllshire, etc."

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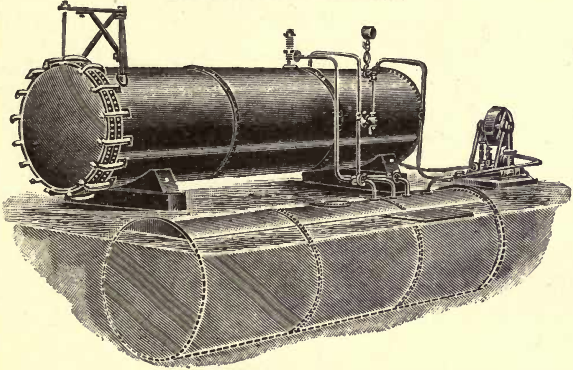

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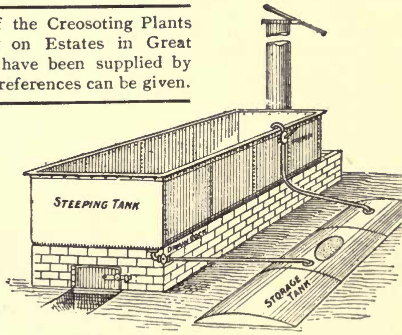

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